A MONOGRAPH

ON THE

FOSSIL REPTILIA

OF

THE CRETACEOUS FORMATIONS.

BY

Richard

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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OF THE

MONOGRAPH ON THE REPTILIA OF THE CRETACEOUS FORMATIONS.

* The *Enaliosauria* of Conybeare were divided into two orders, 'Sauropterygia' and 'Ichthyopterygia,' in a "Memoir on the Classification of Recent and Fossil Reptilia," in the 'Reports of the British Association,' 1859, on the grounds therein assigned, pp. 159, 160.

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TO THE

SPECIES DESCRIBED IN THE MONOGRAPH

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REPTILIA OF THE CRETACEOUS FORMATIONS.

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* For additional remarks on the Iguanodon, see 'Monograph on the Wealden Reptilia.'

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

PART I.

PAGES 1—118; PLATES I—XXXVII, with VIIA and IXA.

CHELONIA (LACERTILIA, &c.).

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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ORDER—*CHELONIA.*

Genus, CHELONE, (Turtles.)

ONE of the earliest, if not the first, indication of the occurrence of fossil Turtles in the formations of the Cretaceous Period, is given by the celebrated anatomist CAMPER, in a 'Memoir on the Petrifactions found in St. Peter's Mount, Maestricht,'* where, referring to some specimens which he had procured for the British Museum, he writes:—"Another very beautiful specimen, a foot and a half long, and about ten inches broad, I have been induced to add, because it contains the anterior part of the scutum of a very large Turtle. Of this Mr. JOHN HUNTER has an analogous bone from the same mountain in his valuable collection, but sent to him under another name. I am convinced it belonged formerly to a Turtle;—first, because I have from the same mountain the entire back of a Turtle, four feet long and sixteen inches broad, a little damaged at the sides, and a pretty large fragment of another Turtle in my possession: secondly, because I have a similar one, but so placed within the matrix, as to show the inside of that piece in the back of a large Turtle I got in London, by the favour of Mr. SHELDON: thirdly, because I have amongst these bones the lower jaw-bone of a very large Turtle, of which the crura, though not entire, are seven inches long, and distant from one another six inches; the thickness is equal to one inch and a quarter."† In a collection of engravings belonging to my

* Philosophical Transactions, 1786.

† Ibid., p. 450.

late father-in-law, William Clift, Esq., F.R.S., there is one of a carapace of a large fossil Turtle, corresponding in size with that mentioned by Camper, and in his style of drawing. It is entitled "Tortue petrifiée trouvée dans la Montagne de St. Pierre pres de Maestricht;" and exhibits the "nuchal" and anterior "marginal" plates; ten "neural" plates, of a rhomboidal figure, carinated, and of nearly equal size, the fifth being six inches in diameter: the eight costal plates of the left side, and the first two and last three of those on the right side. The length of the first costal plate is seven inches, that of the last is little more than three inches; remains of the long and slender ribs are shown extending from the apices of the costal plates, which, in proportion to the length of the entire carapace, and to their own antero-posterior diameter, which is five inches, are extremely short, for in a carapace of a Turtle four feet in length, the costal plates must be supposed to have attained their full extent of ossification. The transverse diameter of the neural plates in this large fossil Turtle from Maestricht is three fourths that of the costal plates at the fore-part of the carapace, and is greater than that of the costal plates at the hind part,—a proportion which I have not noticed in any other Turtle, recent or fossil. The same characters appear in the figures given by M. Faujas St. Fond, of the same large species of Turtle.* Cuvier, whose superior anatomical knowledge enabled him to correct some erroneous remarks which M. Faujas St. Fond had published respecting the Chelonian remains in his 'History of the Fossils of St. Peter's Mount,' arrives at the conclusion, that they belonged to the Turtles, or marine genus *Chelone*, and to a species distinct from any existing Turtle;† but he does not notice the character of the great breadth of the neural plates, as compared with that of the costal ones; he only remarks that the great Maestricht Turtle appears to have much resembled the *Chelone caretta*.

The formation, near Maestricht, in which these Chelonian fossils occur, is the most recent member of the deposits of the Secondary epoch,—the highest and last formed of the cretaceous group: it consists of a soft yellowish stone, not very unlike chalk, and includes "siliceous masses, which are much more rare than those of the chalk, of greater bulk, and not composed of black flint, but of chert and calcedony.‡

Fossil remains of the Chelonian Order were deemed to be of rarer occurrence in the Chalk formations of England, which are apparently of older date than those at Maestricht. The first intimation of such was given by Dr. Buckland, in his 'Bridgewater Treatise' (1836), vol. ii, p. 67, pl. 44′, fig. 3*d*, which is described as a "beak of a small testudo from chalk, in the collection of Mr. Mantell, showing a fibro-cancellated bony structure, very different from the compact shelly condition of the Rhyncolite, for which it may, from its size and shape, be mistaken." Dr. Mantell states, in his 'Wonders of Geology' (1839), vol. i, p. 330, that this specimen is "from the Lewes

* Histoire Naturelle de la Montagne de Saint-Pierre de Maestricht, 4to, 1800, pl. xii-xiv.

† Ossemens Fossiles, 4to ed. 1824, tom. v, pt. 2, p. 242.

‡ Fitton; Proceedings of Geol. Soc., 1830.

chalk," and probably, therefore, from the Lower Chalk. Further evidence of the remains of *Chelonia* in the cretaceous deposit is given in my paper on that subject read before the Geological Society, April 29, 1840, and published in vol. VI, p. 411, of the Second Series of the 'Geological Transactions.' The Chelonite there described and figured was obtained from the Lower Chalk at Burham, in Kent, and consisted of four marginal plates of the carapace, and a few other obscure fragments, sufficient to prove that the species was not of a *Trionyx* or *Testudo;* and as they differed in form from those of the recent species of *Chelone,* with which I compared them, and resembled rather the posterior marginal plates of some Emydians, I stated that this correspondence "rendered it probable that these remains are referable to that family of Chelonia which live in fresh water or estuaries." Subsequent observation of the various interesting modifications by which extinct *Chelones* diminish, as it were, the gap between the marine and fresh-water genera as they remain at the present day, weakened the impression which the character of the marginal plates of the chalk Chelonite first made in favour of its Emydian affinities; and the examination of the beautiful Chelonite, obtained from the same quarries at Burham, in Kent, and relieved from the chalk matrix by Mr. Bensted, described and figured by Dr. Mantell in the 'Philosophical Transactions' for 1841, demonstrated that it is not an *Emys* but a true *Chelone,* as I have stated in the note appended to my paper in the 'Geological Transactions.'

As one of the figures in Dr. Mantell's Memoir, Pl. 12, fig. 2, exhibits the extraordinary character of ten pairs of ribs in the carapace of this rare fossil, permission was obtained for original drawings to be made from the specimen, and these form the subjects of T. I and T. II of the present Monograph.

From the time of CALDESI,* the constancy of the number of pairs of ribs which enter into the formation of the carapace of the Chelonian Reptiles has been confirmed by all subsequent observations. No anatomical fact, perhaps, is better determined, and more plainly and positively laid down, in all handbooks of Comparative Anatomy. Perhaps no monstrosity would sooner arrest the attention, or excite more wonder in the Comparative Anatomist, than the appearance in a recent or fossil Chelonian of a greater number of pairs of ribs in the carapace than 8. When, therefore, I saw the figure 2 of Plate XII of the volume of the 'Philosophical Transactions' for the year 1841, exhibiting not fewer than 10 expanded ribs on the left or entire side of the fossil carapace, and 9 expanded ribs on the mutilated right side of the same carapace, and found the experienced and well-known author appealing† to

* Osservazioni anatomiche intorno alle Tortarughe maritime d'Acque dolce et Terrestre; 4to, 1687.

† Dr. Mantell's words are—"The inner surface of the carapace is also thus displayed (Pl. 12, fig. 2), together with the mode of union and growth of the costal processes, and the attachment of their distal extremities to the osseous border. The accuracy of the drawings renders any detailed description unnecessary."—Phil. Trans., 1841, p. 156.

the accuracy of the drawings as an excuse for omitting any detailed description of the rare fossil, I was at first inclined to infer the existence of an extraordinary anomaly in the construction of this extinct Chelonian of the Cretaceous period; but, having more pleasure in the contemplation of the harmonies and constants of Nature than her wonders, it was with no regret that I found that the error or lusus lay with her illustrator, and not with his subject, as I have ascertained by a careful inspection of the original. The artist has supplied the additional ribs from his imagination; and in the view, in fact, in which his attention was kept more closely to the parts, as in that of the upper surface of the same carapace (Pl. XI, Phil. Trans., 1841), he gives the true number of 8 pairs of carapacial ribs or costal plates; and the author, in reference to the characters of the carapace "as shown in plate XI," states, that "it is composed of eight ribs on each side the dorsal ridge." The correct view of the under surface of the carapace is given in T. II, fig. 1 of the present Monograph.

CHELONE BENSTEDI, *Owen*. T. I, II, and III.

Syn. EMYS BENSTEDI, *Mantell*. Philosophical Transactions, 1841.
CHELONE BENSTEDI, *Owen*. Report of British Fossil Reptiles, in 'Reports of the British Association,' 1841, p. 173.

The fossil in question consists of nearly the whole carapace (T. I), and a considerable portion of the plastron (T. II, fig. 2), with a coracoid bone (T. II, fig. 2, 52, 53).

The carapace includes all the neural plates; the usual number, viz., eight pairs of costal plates (*pl.* 1—8, T. I); and the entire border of marginal plates, save the nuchal and two or three succeeding ones. In the plastron (T. II, fig. 2), the hyosternal (*hs*) and hyposternal (*ps*) bones may be distinguished. The general form of the carapace is elliptical, terminated by a point at the narrower posterior end, which, however, is less contracted than in some other *Chelones*. It is as depressed as in *Chelones* generally, as is shown in the side view T. I, fig. 2. To judge from the unmutilated and exposed neural plates, which are the first, the second, and the sixth to the tenth inclusive, the carapace appears to have been traversed by a median longitudinal crest, from which the sides gently slope with a slight convex curvature, as in *Chelone mydas*.

The more immediate indications of the close affinity of the fossil to the marine Turtles, are given by the incomplete ossification of the costal plates and of the elements of the plastron; the latter being in consequence dislocated from each other; and more especially by the shape and size of the marginal plates (T. II, fig. 1, 6, 7, 8, 9) attached to the third, fourth, fifth, and sixth ribs; as also by the form and length of the coracoid bone.

The neural plates are as narrow relatively as in the ordinary *Chelones*, and differ in this respect from the broad rhomboidal plates in the *Chelone Camperi* of Maestricht. The first and second are long and narrow, with almost parallel sides; they are carinate above, and the first is crossed by the indentation of the juncture between the first and second vertebral scutes. The third and fifth are similarly indented. The eighth, which is the smallest of the neural plates, is crossed near its anterior border, by the impression of the juncture between the fourth and fifth vertebral scutes; this neural plate is 3 lines in length and 2 in breadth:* the ninth expands posteriorly into a triangular form; both these have their middle part raised into a ridge: the tenth plate is suddenly expanded, with angular sides, which slope away from a median longitudinal ridge: this is crossed by a transverse impression just anterior to its junction with the pygal or median terminal plate (*py*) of the marginal series, which is convex above and traversed by a median longitudinal furrow. The margins of this plate meet posteriorly at an open angle. The second to the seventh pairs of costal plates extend along the upper part of only the vertebral halves of the ribs, of which they appear to be expansions. The length of such expanded part of the third rib (*pl.* 3) is 9 lines; its narrow, tooth-like part, before it reaches the marginal plate, is 9 lines; about 3 lines of its extremity is inserted into the deep groove of the concave surface of the sixth marginal plate, *m*6. The width of the interspace between the narrow parts of the third and fourth ribs is 4 lines; the length of the expanded part of the first rib is $10\frac{1}{2}$ lines; the breadth of the expanded part of the first rib is 8 lines; the length of the narrow end of the rib, clear of the marginal plate, is 3 lines. In the superior breadth of the first rib, the *Chelone Benstedi* agrees with existing turtles, and differs strikingly from the Purbeck species. The last short rib (*pl.* 8) sends almost directly backwards a short, narrow, tooth-like process, at right angles to the anterior margin of its sub-triangular expanded part. In *Chelone obovata* it is extended more nearly parallel with the expanded part.

The marginal plates (*m*4 to *py*) have the same general uniformity of size which we observe in the existing *Chelones* (see the Cuts 1 and 2, p. 3, of the 'Monograph on the Reptiles of the London Clay'); the posterior ones are not expanded as in the Purbeck *Chelone*, and in certain *Emydes*, as *Emys serrata*, &c.; but the most decisive evidence against the Emydian affinities of the present fossil is afforded by the form and development of the inferior borders of the marginal plates attached to the fourth, fifth, and sixth ribs (*m*7, *m*8, and *m*9, T. I, II, fig. 1); for these plates, instead of being expanded and extended inwards to join the hyo- and hyposternals and to combine with these elements of the plastron in forming the lateral supporting wall of the carapace, are not so much developed in breadth as the same parts of the posterior marginal plates, but form with them an even free border, as in other *Chelones*, in which not any of the

* In all *Emydes* the proportions of this plate, when it is not suppressed, are the reverse of those in the fossil.

marginal plates are joined with the sternum. This unmistakeable evidence of the marine character of Mr. Bensted's beautiful fossil is unequivocally shown at *b*, in Pl. 12, fig. 2, of the 'Philosophical Transactions' for 1841, in which, nevertheless, the fossil is referred to the genus *Emys*.

With reference to the general imperfect ossification of the carapace, the deductions in favour of the marine nature of the Chalk Chelonite might be invalidated by the hypothesis, that it was the young of some very large species of *Emys;* but the existing Emydians at the immature period when they exhibit the incomplete ossification of the carapace and plastron, have the marginal plates opposite the lateral processes of the hyosternals and hyposternals joined with those processes by an inward development of their inferior border, which is suddenly and considerably broader than the inferior border of the contiguous free marginal plates.

The outer contour of the tenth, eleventh, and twelfth plates of the *Chelone Benstedi*, projects in the form of a slight angle, and they thus differ from the same parts of *Chelone mydas* and *Chelone obovata;* most of the others have a straight free margin. The marginal plates appear as if bent upon themselves to form their outer margin, at a rather acute angle, receiving the extremities of the rib in a depression excavated in the concavity of the angle; they are nearly twice as long in the direction parallel with the margin of the carapace than transverse to it, and they are traversed in the latter direction, along the middle of their upper surface, with the groove or impression of the marginal scutes. The free edge of the upper plate of the marginal pieces is slightly notched above the insertion of the rib, and they correspond with those of the Chelonite, from the Burham chalk pit, in the collection of Sir Philip de M. Grey Egerton, Bart., F.R.S.

The form of the median or vertebral scutes of the perishable "tortoise-shell," may be traced by their somewhat wide and moderately-deep impressions. They progressively diminish in size from the second to the fifth, which is the smallest, and which covered the ninth and the major part of the eighth and tenth neural plates; but their relative breadth and the outward extension of their lateral angles correspond, like the characters of the more enduring parts, with the type of structure of the marine turtles. The breadth of the first vertebral scute is 1 inch 8 lines, that of the second scute is 2 inches, that of the fifth scute is 1 inch.

The coracoid is a bone that varies in form so as to be very characteristic of the different genera of Chelonians; it is a triangular plate in *Testudo*, a more elongated triangle in *Chelys*, a broad, bent, elongated plate in *Trionyx*, a narrower bent plate in *Emys*, a long, straight, slender bone, slightly expanded and flattened at the sternal end, in *Chelone:* now it is precisely the latter form that this bone (T. II, fig. 2, 52, 53), fortunately preserved in the present specimen, here exhibits, showing that the same modifications of the skeleton, in reference to the actions of swimming, are combined in the past as in the present species of *Chelone;* it is 1 inch 7 lines in length,

cylindrical at its humeral half, and gently expanded to a breadth of 3 lines at its sternal end. The proportion which this bone presents of one fourth the length of the carapace is only paralleled in the existing *Chelones;* it is much shorter in the *Emydes.*

The hyosternal and hyposternal bones resemble rather those of the Turtles than of the young Emydes; certainly no *Emys*, with a carapace 5 inches in length, presents such forms as these bones exhibit in the present fossil; several rays or pointed spines of bone are developed from the anterior half of the median margin of the hyosternal piece, as in *Chelone caretta;* the rest of the margin continues to form the circumference of the large central aperture of the sternum. The hyposternal sends similar rays from the posterior half of its outer margin, leaving the anterior half to join, probably the same proportion of the outer margin of the hyosternal, so as to form a deep, lateral, angular notch of the sternum. The length of the hyposternal is 1 inch 2 lines. The epi-, ento-, and xiphi-sternal bones are not preserved.

From the preceding description, it must be obvious, as has been already observed, that the present Chelonite of the chalk can only be supposed to belong to the genus *Emys*, on the supposition that it is a very young specimen of some unusually large species; but against this supposition, the pointed form of the hind end of the carapace, the regularity of the size of the marginal plates, the non-development of the lower margin of any of these plates for a junction with the plastron, the long and slender coracoid, the narrow elongate form of the vertebral plates, and the broad vertebral scutes, collectively and separately militate. Whilst in all these modifications, the Turtle from the Chalk so closely corresponds with the true *Chelones*, that I cannot hesitate to refer it to the marine family of the order.

From the breadth of the xiphisternals in the remains of this species first described by me, I was induced to suppose that a new subgenus (*Cimochelys*) of marine Turtles was thereby indicated, having a closer affinity to the *Emydes* than the typical species; and the same affinity seems to be shown by the more regular elliptical form of the carapace of Mr. Bensted's beautiful specimen. The structure of the cranium, when this desirable part of the skeleton is discovered, may confirm the propriety of the sub-generic distinction; but the numerous decided marks in other parts of closer affinity to *Chelone* leave no alternative than to regard the fossil species of the chalk as a member of that genus.

It differs from all known species, especially the sub-carinated species of Sheppey (*Chelone subcarinata* and *Chelone subcristata*), in the form of the carapace, which is more truly elliptical than in any other species with which I am acquainted.

A second specimen of *Chelone Benstedi*, of the same size with that above described, also obtained from the lower chalk at Burham, in Kent, and now in the fine collection of J. S. Bowerbank, Esq., F.R.S., gives a better view of the upper surface of the carapace, but the marginal plates have been dislocated and pressed inwards beneath the narrow pointed ends of the ribs. All the neural plates are narrow and carinate

above. They are a little broader in front than behind. The slight angular production of the middle of the outer border of the posterior marginal plates is somewhat better marked than in the preceding specimen, and it gives a serrated character to that part of the circumference of the carapace which is formed by those marginal plates.

An upper view of Mr. Bowerbank's specimen is given in T. III, fig. 1; a side view in fig. 2; an oblique front view, showing some of the anterior marginal plates in fig. 3; and an outline of the transverse vertical section of the Turtle in fig. 4: all of the natural size.

CHELONE PULCHRICEPS, *Owen.* T. VII *A*, figs. 1, 2, 3.

Report on British Fossil Reptiles, Trans. British Association, 1841, p. 172.

With the exception of a few more or less mutilated mandibles, no parts of the skull of a Chelonian reptile have been, hitherto, discovered in the chalk itself, either at Burham or elsewhere in England; but I have had the opportunity, through the kindness of the Rev. Thomas Image, M.A., of Whepstead, of examining and comparing the fossil cranium of a small turtle from the green-sand which underlies the chalk. The specimen was discovered near Barnwell, in Cambridgeshire. The general form of the skull is elongate and depressed; and it is chiefly remarkable for having the nasal bones (15) marked off by a suture from the pre-frontals (14), being a return to the typical characters of the vertebrated cranium, which I have also noticed in the skull of a larger turtle, from the Portland Stone, where, however, the course of the suture is different.

The characters of the genus *Chelone* are clearly expressed in the skull of the *Chelone pulchriceps,* by the extensive roof of bone over-arching the temporal fossæ, and by as large a proportion of this roof being formed by the post-frontals (12) as in existing *Chelones.* The orbits are also large, and their superior interspace is broad.

The median or true frontals (11) form a small proportion of the upper border of the orbits; the anterior extremities of the median frontals, instead of converging to a point, are extended forwards, between the pre-frontals, in a broader proportion than in the Portland turtle, and are obliquely truncated: it is only in the genus *Chelys* among existing Chelonians, that the pre-frontals are thus separated from each other; but in the *Chelys,* the intervening extremities of the frontals are continued to the upper border of the external nostril. In the present fossil cranium, the median extremities of the pre-frontals are arrested at the distance of four lines from the nasal aperture, which is bounded above by two distinct nasal bones (15); these bones are joined by suture to the frontals, to the pre-frontals, and to the superior maxillaries (21); the nasal processes of which extend upward, and exclude the pre-frontals from the nasal boundary. The superior maxillaries are traversed obliquely by a large and

deep scutal impression, above which the superior maxillary forms a convex prominence at the anterior part of the orbit. The groove, which traverses the frontals, is as strongly marked; that which impresses the post-frontals is fainter. The expanded trumpet-shaped portion of the tympanic bone comes nearer the upper margin of the cavity than in existing *Chelones*.

The palatal bones (20), have no palatal process anterior to the inner nostril, as in the *Chelone cuneiceps** and modern Turtles; but are situated behind that aperture, as in *Emys* and *Trionyx*, and the vomer does not penetrate between them. The palatal processes of the intermaxillary and maxillary bones form an unusually prominent angular ridge, running nearly parallel with the trenchant margin of the jaw; the bony palate is not extended along the middle line beyond the intermaxillaries, which here enter into the formation of both the inner and outer nostrils. The pterygoid bones present moderately wide and deep external emarginations.

The following are the chief dimensions of this fossil skull:

	In.	Lin.
Length of the cranium from the occipital tubercle . . .	2	4
Breadth of the cranium above the tympanic cavities . . .	1	6
Depth of the cranium at the parietal bones	1	0
Antero-posterior diameter of the orbit	0	9
Breadth of the interorbital space . . , . . .	0	8

The supracranial scutation of the *Chelone pulchriceps* much resembles that of the *Chelone Couanna*. A large oval syncipital scute defending the middle region of the epicranium, and being surrounded by the smaller "frontal," "superorbital," "parietal," and "occipital" scutes: the bones supporting the latter have, however, been too much mutilated to allow of their proportions and forms being determined. The fronto-nasal scutes are each bounded behind by well-defined bold curved lines, convex towards the frontal scute, and deeply indenting the frontal bones. Amongst the existing *Chelonia*, the character of the distinct nasal bones has been, hitherto, met with only in an Emydian species, on which the sub-genus *Hydromedusa* has been founded. The modifications of the bony palate in the *Chelone pulchriceps* afford another indication of its Emydian affinities.

Chelone Camperi, *Owen*. (?) Tab. V.

Large Turtle, *Camper*. Philosophical Transactions, vol. lxxvi, 1786.

I am induced provisionally to refer to the above species the two large bony plates or scutes figured in T. V, on account of their size, their shape, and especially their carinate structure. They have a smooth exterior surface, marked only by faint lines radiating from the median "carina" or ridge. They are thickest at this part, which

* Monograph on the Chelonia of the London Clay, t. xv, fig. 3, 20.

is from one to two lines, and become gradually thinner to their peripheral border, which, however, is too much fractured to show whether it has been terminated by a dentated suture like the neural plates, which unite with the costal plates in the ordinary *Chelones.* The degree of thinness of the actual margins of the large scutes in question shows that they were not suturally united to costal plates. On the hypothesis, therefore, that they are the median or neural plates of a Turtle, they can only be referred, as not uniting laterally with costal plates, to the ninth and tenth of the series of neural plates, which are under the same circumstances, and which also differ from the eight preceding plates, in having contracted no osseous continuity or adhesion to the subjacent neural spines. In order to test this particular conformation I carefully excavated the chalk matrix beneath the median part of both scutes to beyond the middle of it, and exposed only a smooth concave surface: there was no trace of the median ridge, which is continuous with the summit of the spine, in the first eight neural plates of the Chelonia.

But besides the two plates, the exterior surface of which is exposed, there is a third plate, the position of which is reversed, and which has slipped under one of the scutes that has retained its natural position. A portion of a fourth similar plate is also present in a similar reversed position in the same block of Chalk. This fact, together with the thin borders of the plates, leads me to suspect that they may belong to the series of marginal plates of a large Turtle, notwithstanding the open angle at which the sides diverge from the median ridge, which, in that case, must have formed the outer and anterior border of the carapace.

On the hypothesis that these large plates have belonged to a Turtle, they indicate an individual with a carapace between forty and fifty inches long; as large, for example, as that of which CAMPER makes mention in the memoir above quoted. There is a possibility, however, that those large scutes may have belonged to some Saurian reptile, although the probability is small, on account of the absence of any rugosities, pits, or other sculptured character which marks the exteroir surface of all the dermal bony scutes of Saurians hitherto found. It is possible that the *Polyptychodon,* or the *Mosasaurus,* if their skin was so defended, might have had light and smooth scutes; but the balance of evidence is at present in favour of the Chelonian character of those in question. Their microscopic structure shows that they have not belonged to a cartilaginous fish, and it agrees pretty closely with that of the osseous tissue of unquestionably Chelonian neural plates of smaller size, from the chalk formation.

Another circumstance which also inclines me to view the large plates above described as being Chelonian, is the corresponding thinness of the costal plates where they are unattached to the subjacent ribs in the specimen from the Burham Chalk-pit, figured in T. VI, fig. 3. The outer surface of these plates is also smooth, or at most marked by fine striæ. The borders by which they are in contact do not show

any very distinct character of suture, but appear to have been joined by a wavy line. The length of the rib which projects beyond the conjoined costal plate is considerable, being proportionally greater than in the much smaller *Chelone Benstedi;* and the free portion of the rib is narrower, with a smoother upper surface, evidently indicating a distinction of species. The portion of carapace in question may belong to a young *Chelone Camperi.*

Of the marginal plates of that species only the anterior ones appear, as yet, to have been discovered at Maëstricht; but the liability of such slightly attached parts to be scattered and lost, renders their discovery in natural connection, as in the specimens in T. V, more remarkable, perhaps, than their absence, and affords, at least, no sufficient grounds for the speculation of Faujas St. Fond, that they were cartilaginous in the large Turtle from Maëstricht. The outer surface of the bones of the carapace of the Chelonian Reptiles which actually retain the marginal plates in a gristly state, is characterised by a sculptured character, well shown in several plates of a former Monograph, ex. T. XVI, but of which no trace exists in the *Chelone Camperi,* from Maëstricht, any more than in the neural or marginal plates in Tab. V, or the costal plates in Tab. VI of the Chelonites from the upper chalk of Kent.

CHELONES INDETERMINATÆ.

Various portions of the fossilised skeletons of Chelonian Reptiles have been kindly submitted to me by Mrs. SMITH, of Tonbridge Wells; by J. S. Bowerbank, Esq.; and by THOMAS CHARLES, Esq., of Maidstone, from which specimens I have selected the subjects figured in T. IV, T. VI, and T. VII *A.*

The specimen, fig. 8, T. VII *A*, from the Collection of J. S. Bowerbank, Esq., is of a similar nature to those above described and figured in T. V; but it is rather smaller, and is more decidedly shown to belong to the marginal series of scutes by the unsymmetrical development of the two sides which slope away from the median ridge; and this, also, is oblique: the sides form a less open angle: their substance, which is hardly a line in thickness at the meridian ridge, gradually thins off to the border, which is produced on one side into a number of dentated processes, that to all appearances are natural.

There are two similar but rather smaller marginal scutes in the same Collection.

Mr. John Quekett, the Assistant Conservator of the Museum of the Royal College of Surgeons, has kindly prepared sections for the microscope from the preceding specimens, and the form, size, and arrangement of the bone-cells agrees with those in similar preparations from the scutes of the recent Turtle.

The portion of mandible, T. VII *A,* figs. 4 and 5, resembles that of the *Chelone planimentum,* T. IX, of a former Monograph, and of some of the Eocene Turtles from Bracklesham, figured in Mr. Dixon's work 'On the Tertiary and Cretaceous Deposits of Sussex,' Tab. XIII, in the great extent of the bony symphysis; but this differs in

having the upper surface traversed by two longitudinal furrows, slightly converging as they approach to the point. The outer or alveolar borders are obtusely rounded; and are perforated, as in most Chelonians, by a series of small vascular foramina: the rounded border increases in breadth as it extends backwards where it is continued upon, or forms, the outer surface of the beginning of the ramus of the jaw. The commencement of the coracoid process rises from the inner border of the ramus which is continued from the hinder and upper border of the broad symphysis. In this character, also, the present mandible differs from all that I have previously seen, either fossil or recent. In its general form it resembles, like some of those from the Bracklesham Clay, the mandible in the *Trionycidæ*, rather than that in the existing *Chelones*. The specimen is in the Collection of James S. Bowerbank, Esq., F.R.S.

In the same rich depositary of British Fossil remains is the portion of a Chelonian mandible, T. VII*A*, figs. 6 and 7. It has formed part of a longer, narrower, and more pointed lower jaw than the one above described. The bony symphysis is much shorter; the rami longer, deeper, and more regularly convex on their outer side. It thus, likewise, presents the characters rather of a *Trionyx* than of a modern *Chelone;* but the modifications of the lower jaw, in indubitable species of true Turtle from the older Tertiary deposits, forbid a conclusion against its having belonged to a similarly modified species of *Chelone*.

I am indebted to Mr. Catt, of Brighton, for the specimens of the right scapula and coracoid, in almost their natural juxta-position, of a Turtle which must have been about two feet in length, from the chalk, T. VII*A*, fig. 9. The letter *a* shows the surface contributed by the scapula to the humeral joint, the letter *b* that by which it was united with the coracoid: *c* is the base of the acromial process or clavicle, which has been sent off in the same oblique direction as in the recent Turtles; *d* is the beginning of the body of the slender scapula. The coracoid has been rotated, so as to show its scapular surface at *b:* that which it contributed to the shoulder joint is shown at *a:* the long and slender shaft of the coracoid and its very gradual expansion is eminently characteristic of the marine nature of the species to which it belonged.

In Tab. VII*A*, fig. 10, is shown the opposite side of the right coracoid of a Turtle of double the dimensions of that from which the preceding specimens came. It is from the chalk-pit at Burham, so fertile in fine fossils, and forms part of the collection of Mrs. Smith, of Tonbridge Wells. The margin of the articular end is more produced than in the *Chelone mydas,* and, as in the preceding fossil, the articular surface *b* for the scapula is relatively less in proportion to that for the humerus *a,* than in the same recent Turtle: the slender beginning of the shaft of the bone is more compressed, less triedral. I estimate the fossil fragment, by the proportions of that of the *Chelone mydas,* to have been part of a coracoid of one foot in length, and calculating the proportions of the carapace by those of the *Chelone Benstedi,* it must have been about three feet six inches in length in the Turtle from which the coracoid in question came.

T. IV, fig. 1 is the slender portion of the entosternal, *e s*, and a fragment of the right hyosternal of a turtle, which must have been about one foot eight inches in length.

Figure 2 gives an inside view of a rib, with the connate costal plate, the gradual narrowing of which towards the free end of the rib resembles that in the *Chelone Benstedi*.

Figure 3 is a similar specimen from the carapace of a larger turtle, with the neck of the rib more freely relieved from the connate costal plate.

Figure 4 is a more mutilated example of a larger rib and costal plate.

Figure 5 is the right hyposternal of the *Chelone Benstedi*, and has belonged to a specimen not larger than either of those figured in T. I—III.

Figure 6 is the humeral end of the connate scapula and clavicle of a turtle.

Figure 7 is the outer side of a marginal scute of a large turtle.

Figure 8 is the left humerus of a turtle, which differs from that of the existing species in the greater expansion of its distal end.

Figure 9 is the left ulna of a turtle, belonging to a larger example than that to which the humerus belonged.

I have been favoured with the opportunity of inspecting portions of the skeleton of a large Chelonian obtained by Mrs. Smith, of Tonbridge Wells, from the lower chalk at Burham, Kent, and skilfully relieved from their mineral bed by that lady. The principal bones consist of two series, one containing five, the other three and parts of two, of the marginal plates of the carapace, in natural connection, and from that part of the margin where they receive the extremities of the vertebral ribs (T. VI, figs. 1 and 2). These marginal plates in *Chelone mydas* are three-sided, and have two thick terminal borders by which they are united, suturally, to one another: of the three free surfaces, the one, directed towards the interior of the body, is concave and characterised by a deep depression for the reception of the tooth-like extremity of the rib (fig. 2); the other two (upper and under) surfaces meet at an angle, which is produced at certain parts to form the marginal dentations of the lateral and posterior parts of the carapace in that species of turtle, but is more open and obtuse in the marginal plates at the anterior part of the carapace. In the fossil the marginal plates have the general characters of those of the genus *Chelone*, but differ from those of the *Chelone mydas* in being more concave on the central or perforated side, and they are also concave at the upper side, and in a slighter degree at the under side; these sides likewise meet at a more acute angle, and this angle is produced into a sharper and more continuous ridge; but this ridge subsides at one end of the series of plates in fig. 1, and the upper and under sides gradually meet at a more open angle, which is rounded off in the first of the series. This plate, therefore, answers to the third marginal plate in the *Chelone mydas*, or that which receives the end of the first expanded vertebral rib; and the remainder, therefore, to the fourth, fifth, sixth, and seventh marginal plates: now these are precisely the marginal plates in the *Emys*

which have their inferior margins developed inwards, and articulated by suture to the lateral wall of the carapace: but these margins not being so developed or terminated in the present fossil, but, on the contrary, being inferior to the upper margin in breadth,* and terminating like that margin in a blunted edge, prove the present Chelonite to belong, like the smaller Chelonite from the same chalk-pit already described, to the marine genus *Chelone.*

The length of the carapace of the *Chelone mydas* is about nine times that of the sixth marginal plate, whence I calculate the length of the carapace to which the marginal plates here described belonged to have been about fourteen inches.

The following admeasurements will show the different proportions of the marginal plates of the present specimen as compared with the corresponding ones of a *Chelone mydas* of similar general size:—

	Fossil Chel.		*Chel. mydas.*	
	In.	Lin.	In.	Lin.
Length of the series of five plates in a straight line .	7	3	8	2
Breadth of the upper surface of the third (fifth) .	1	1	0	10
Interspace of costal depressions	1	2	1	6

Thus the marginal plates of the chalk turtle, besides being more concave, are broader in proportion to their length, or antero-posterior diameter. In these respects they correspond with the form of the marginal plates in the *Chelone Benstedi,* but more evidence must be had, before these large fossil marginal plates can be referred to a larger and older specimen of the species.

There are other two marginal plates imbedded in the same portion of chalk, with their upper, smooth, slightly concave surfaces exposed; and the toothed or sternal extremities of three of the vertebral ribs, which by their length and size also prove this specimen to be a Turtle. One of these fragments of rib measures $5\frac{1}{2}$ inches, and the expanded plates developed from each side of its upper surface are concave on their exterior surface, which is flat or slightly convex in *Chelone mydas.*

A separate portion of chalk from the same pit contains the scapula and its acromial branch or anchylosed clavicle, with the articular surface which joins with the coracoid and humerus. The angle at which the scapula and clavicle meet is more open in *Chelone* than in *Emys* or *Chelys:* the present specimen presents the same angle as in the Maëstricht *Chelone* figured by Cuvier,† in which it is rather more open than in the recent species of turtle. A broad, thin, slightly concave plate of bone appears, by the radiation of the fine striæ at its under part, to represent the expanded parietal bone of the cranium.

* The upper margin, which is distinguished by a slight notch where the costal groove leads to the pit, is broader than the lower one, in these plates of the *Chelone mydas;* but the difference is less than in the present fossil species.

† Ossem. Foss., tom. v, part ii, pl. xiv, fig. 5.

Genus, PROTEMYS, *Owen*.

In the operations of quarrying a rock of the hard variety of the gray arenaceous limestone, called "Kentish Rag," which belongs to the "Green-sand" Formation, near the town of Maidstone, in Kent, Mr. Bensted, the owner of the quarry, had the good fortune to discover the dislocated remains of the carapace and plastron of a Chelonian reptile, which remains were grouped together in a slightly dislocated mass, having a circumference of three feet. This fine specimen, still unique of its kind, has been liberally transmitted, by Capt. Guise, F.G.S., its present possessor, to me for the purposes of being described and figured in the present Monograph.

It represents, as will be shown in the account that follows, a distinct sub-genus in the Family *Emydidæ*, which may be characterised as follows:—

Sternum dilatatum, per gomphosin cum testâ conjunctum, suturis hyo-et hypo-sternorum in medio lateribusque sterni interruptis.

PROTEMYS SERRATA, *Owen*. Tab. VII.

The specimen consists of the principal part of the carapace and a small part of the plastron. The carapace presents an ovate form, being apparently widest about two thirds from the nuchal plate. Both the nuchal (T. VII, *ch*) and the pygal (ib., *py*) plates are preserved, and the total length of the carapace is 1 foot $1\frac{1}{2}$ inch. The extreme breadth of the carapace at the part above indicated appears to have been about 9 inches. The carapace is moderately convex, but becomes concave near the margin of the hinder half, by a slight upward curve of the marginal plates there.

The nuchal plate is tranversely oblong, slightly but widely emarginate anteriorly, 3 inches 9 lines in transverse length, 1 inch 2 lines in the axis of the carapace. The first vertebral scute, *v* 1, advances within three lines of the anterior border of the nuchal plate, which bears the impressions of a small nuchal scute 10 lines wide, of the first marginal scute, and of part of the second marginal scute on each side.

The first costal plate, (*pl.* 1,) articulates anteriorly with the nuchal and first marginal plates, *m* 1, and is connate with the subjacent rib to within half an inch of its pointed end, which penetrates or abuts against the third marginal plate, *m* 3. It is impressed by the triradiate line of union of the first, *v* 1, and second, *v* 2, vertebral scutes with the first costal scute. The rib forms a strong projection on its under surface, as is shown by the impression on the left side of the carapace. The length of the first costal plate, exclusive of the free end of the rib, is 2 inches 8 lines. The first neural plate is lost. The second, *s* 2, is long and narrow, and has been, apparently,

notched posteriorly, between the two truncate angles. Its length is 1 inch 5 lines; its breadth 6 lines: there is no appearance of a carina on its upper surface. The second costal plate, *pl.* 2, is 3 inches 2 lines in length, 1 inch 4 lines in breadth; it is slightly concave in the axis of the carapace; convex in the direction of its own length or across the carapace. On the right side it is fractured, and its outer end is overlapped by the dislocated fourth marginal plate, *m* 4, into the upper border of which the free end of the rib, which now projects below it, was implanted. The upper surface of the costal plate is impressed by the triradiate line of union of the second vertebral scute, *v* 2, with the first, *c* 1, and second, *c* 2, costal scutes. The third, *pl.* 3, and fourth, *pl.* 4, costal plates have their median ends straight with the posterior angles truncate. About seven lines of the free end of the connate rib projects beyond their broad outer ends. Beyond these the carapace is broken through by the pressure of the plastron from below: the upper surfaces of the conjoined hyposternals appear at *ps, ps,* the dislocated parts of the carapace, which were above them, having been removed. The outer portions of the fifth and sixth costal plates are seen on the right side, terminating the one, *pl.* 5, between the seventh and eighth marginal plates, the other, *pl.* 6, between the eighth and ninth marginal plates. The seventh and eighth, *pl.* 7, *pl.* 8, costal plates are preserved on the left side. The median ends of the eighth pair seem almost or quite to have met anterior to the ninth neural plate, *s* 9, as in the *Emys levis*,* the ninth plate presents a triangular form with the apex turned forwards: the breadth of its base is 1 inch 7 lines, its length is 1 inch. The tenth neural plate is a hexagonal one, 1 inch 10 lines in length. It articulates immediately with the pygal plate, *py,* which is subquadrate, rather broader behind, where it is notched in the middle. Its length is 1 inch 5 lines; its breadth 1 inch 8 lines. Not any of these neural plates are carinate.

The left hyosternal (*ps*) has been displaced, so that its under or outer surface would be in view in the block displaying the upper surface of the carapace, T. VII, were not the major part of its substance retained in the other half of the block, which therefore shows in part the contour of its upper or inner surface, T. VII *A*, *ps*, from which, however, the produced outer and anterior angle is broken off, that part remaining attached to the other moiety at *ps*, T. VII, where it dips beneath the border of the carapace. It is this produced angle which, bending upwards and forwards, effects the union between the plastron and carapace at the fore part of the lateral wall, by its insertion into the carapace; and it affords the chief proof of the Emydian affinities of the *Chelonite* under consideration.

Yet in some respects, the hyosternal in the fossil resembles more that of a young than of an old Emydian: its median border is not straight, and the concavity of the hinder half of that border indicates a persistent vacuity in the middle of the bony plastron;

* Monograph on the Reptiles of the London Clay, t. xxii, fig. 1.

the posterior border is convex, showing that it was not united in its whole extent to the corresponding anterior border of the hyposternal.

With the broad nuchal plate (*ch*) is articulated the first marginal plate *m* 1, of the right side: its upper surface is square, and is impressed by the junction of the first costal scute with the second and third marginal scutes. The second marginal plate is lost. The third is displaced, and its concave side is turned upwards: the upper and under walls of the concavity are of almost equal extent, and meet externally at a right angle. Unless the back part of this plate has been turned forwards, it differs from the corresponding plate in the Emydians in not having the inner concavity confined to the posterior part, but extending its whole length, as in Thalassians; its proportions, however, are such as we find in the genus *Emys*. The fourth marginal plate, *m* 4, has its inferior and superior walls equally produced, as in Emydians, and meeting at a right angle: it articulates with the second costal plate, and probably, also, with the hyosternal below, but it has been displaced upwards. The fifth marginal plate is lost. Only the outer margin of the sixth, *m* 6, is produced; this also shows an upper and an under plate meeting at a right angle. The seventh marginal plate, *m* 7, which is preserved on the left side, although fractured, shows its rapid progressive compression towards its posterior border. The eighth marginal plate, *m* 8, is a broad, subquadrate, depressed plate, with a thin outer margin, and the thicker inner margin slightly produced into the angle between the fifth and sixth costal plates: its upper surface is concave, and impressed with the T-shaped union of the third costal scute with the eighth and ninth marginal scutes. The ninth marginal plate, *m* 9, presents a similar form; its outer border is injured. In the tenth marginal plate, *m* 10, the impression of that border is left on the matrix, showing that it had an angular notch. The same character is as strongly marked in the eleventh marginal plate, *m* 11, and the pygal plate, as has been already observed is notched at the middle of the posterior border. It is from the consequent serrated character of the hinder border of the carapace that the specific name has been taken.

Compared with the existing species of the genus *Chelone*, the present fossil differs greatly in the completeness of the ossification of the carapace, due to the extension of the costal to the marginal plates: in the form and proportions of the marginal plates, especially from the first to the seventh inclusive; and in the form of the recognisable elements of the plastron, more particularly in the curved and produced angle of the hyosternal. But when we compare it with some of the extinct Turtles of the Eocene epoch, as *e. g.*, *Chelone longiceps*, *Chelone convexa*, and *Chelone subcarinata*, the difference in regard to the extent of ossification of the costal plates is less; whilst the persistent partial want of union between the elements of the plastron in the present fossil, approximates that part of its skeleton to the condition of the plastron in the Eocene *Chelones* above cited, in which the ossification of the plastral elements has proceeded further than in the typical Turtles.

In these extinct species, the life-periods of which successively stretch backwards in time from the oldest Tertiary to the newer Secondary Epochs, there is plain evidence of a gradual breaking down of the distinctions that now trenchantly divide the fresh-water from the marine species: the actual interval being then filled up by several well-marked species, that have apparently perished.

The Thalassian affinities of the Emydoid *Chelones* of the Eocene Period were, nevertheless, in some instances well established by the structure of the shell, and by the forms and proportions of the limbs,—parts, which it is important to bear in mind, are more constant in their nature than the dermal ossifications on which the solidity or otherwise of the carapace and plastron depends. And it must also be remembered, that with the transitional species, there were associated good typical forms of Turtle, *e. g.*, *Chelone planimentum* and *Chelone crassicostata,* as well as of Fresh-water Tortoises; *e. g.*, *Emys levis, Emys bicarinata, Platemys Bullockii.*

The *Chelonite* from the Maidstone Green-sand, which forms the subject of the present section, deviates from the typical Emydian structure in the arrest of the dermal ossification requisite for the complete solidification of the plastron, and, perhaps, also in the form of the third pair of marginal plates; but, with the exception of this doubtful point, the structure and form of every other element of the carapace are more strictly Emydian, than in the most modified of the Eocene *Chelones* above cited; and the Emydian affinity is more decisively shown in the form of the hyosternal element, T. VII and VII*A*, fig. 1, *hy*. The departure of which from that of a mature typical *Emys* does not bring it so near to the form of the same element in the typical *Chelone*, as it does to that of an immature *Emys,* T. VII*A*, fig. 1*. In the nature and amount of departure from the Emydian type recognisable in the *Protemys serrata,* there is plainly to be seen an arrest of the development of the plastron, which so far as it has proceeded, has followed that type: there is no trace of a deviation from the embryonal common fundamental pattern of the part towards the special modifications characteristic of the genus *Chelone.*

In the small Turtle from the Chalk (*Chelone Benstedi*) the ossification has extended from the hyosternal and hyposternal centres by many diverging rays; the inferior plates of the marginal bones, T. II, fig. 1, 4—12, are feebly and subequally developed throughout; and there are other differences from the *Protemys serrata* of the Green-sand, which no degree of immaturity in the Chalk specimens exhibiting them would explain, as, *e. g.*, the carinated neural plates, T. I and III, *s, s,* and the pointed pygal plate, T. I, fig. 1, *py.*

Were a recent form of *Emydian,* so modified as the large species from the Maidstone Green-sand, to be presented to the study of the modern Erpetologist, one cannot doubt, but that it would be referred to a distinct sub-genus in the Fresh-water family; and I have accordingly characterised such, as far as the condition of the *Chelonite* in question will permit. It is to be hoped, that future discoveries may bring

to light the modifications of the head and limbs of the *Protemys:* from those of the plastron we may infer that the species was more aquatic in its habits than the typical Emydians. The *Protemys serrata* may have been an Estuary species, and its discovery in the same formation and quarry as that in which the remains of an Iguanodon have been found, adds probability to the explanation of the occurrence of the latter in a Green-sand or Neocomian Deposit, on the supposition that the carcase had been drifted out to sea.

ORDER—*LACERTILIA.*

In passing from the Tertiary to the Secondary periods of Geology, in quest of the evidences of Reptilian organisation, we have found no material change in that of the Chelonian order; the characters by which the marine species are now generically separated from other *Testudines* of Linnæus, and which were not deemed worthy of that distinction by the great systematic reformer of Natural History, are recognisably retained in the old Turtles, the contemporaries of the Ichthyosaurs, Plesiosaurs, Pterodactyles, and Belemnites, that swam the ocean in which the Corals and Sponges lived, which deposited the main part of the material that now constitutes our Chalk Downs. The differences which are traceable on a comparison of the Turtles of that period with those of the Tertiary deposits and of the actual seas, merely prove them to have been distinct species, with some slight indications of a nearer affinity to the Emydian type of structure than we observe in the present representatives of the genus *Chelone.*

The Lizards of the present day are characterised, with the exception of one genus, *Gecko*, by the same cup-and-ball articulation of the vertebræ as the modern Crocodiles, viz. with the cup at the fore part of the body of the vertebra and the ball at the back part, an arrangement signified by the term "procœlian," as applied to such vertebræ. The fossil Lizards of the Cretaceous period, whether terrestrial, amphibious, or more especially modified for marine life, present the same procœlian type.

Tribe, REPENTIA.

Genus, RAPHIOSAURUS, *Owen.*

'Transactions of the Geological Society,' vol. vi, 2d Series, p. 413, April, 1840.

Species, *Raphiosaurus subulidens*, Owen, (Tab. X, figs. 5 and 6).

Report on British Fossil Reptiles, 'Trans. of British Association,' 1841, pp. 145, 190.

In a Memoir communicated to the Geological Society of London in 1840, and in

my 'Report on British Fossil Reptiles,' published in the volume of 'Reports of the British Association' for 1841, p. 145, I proposed the name of *Raphiosaurus** for a genus of small extinct lacertine *Sauria,* characterised by slender awl-shaped teeth, attached by anchylosis in a single series to the bottom of a shallow alveolar groove, and to the inner side of an outer wall or parapet of the same groove; thus corresponding with that type of saurian dentition called 'pleurodont' amongst modern Lizards.†

The specimen figured in T. X, figs. 5 and 6, was discovered in the Lower Chalk near Cambridge, and forms part of the rich collection illustrative of the Cretaceous Formations of Cambridgeshire, in the possession of JAMES CARTER, Esq., M.R.C.S., to whose kindness I am indebted for the opportunity of describing the specimen. It consists of a considerable portion of the dentary part of the lower jaw, and contains twenty-two of the above-described teeth, arranged in a close series: in fig. 5 some teeth are shown in place; in fig. 6, *a*, *b*, and *c* show teeth with the crown broken off; and below fig. 6 is the groove or incomplete socket of a shed tooth.

At the period when this fossil was described,‡ the only vertebræ of a lacertine Saurian, which at all approximated to the proportions of the species indicated by the jaw and teeth of the *Raphiosaurus,* were those which Sir Philip de M. Grey Egerton, Bart., had kindly submitted to my inspection, and which are figured in the volume of the 'Geological Society's Transactions' already cited.§ That chain of vertebræ was discovered in the lower chalk of Kent, at Burham pit, and manifested specific distinctions from the vertebræ of the existing genera of Lacertians, with which I was able to compare them in 1840; and at that time I could only suggest, when pressed for a closer determination, that, on the hypothesis of their having belonged to the same species as the fossil Lacertian from the Cambridge Chalk, they must be referred to a Lizard generically distinct from any known existing species. Other specimens with which my lamented friend Mr. Dixon subsequently supplied me, have rendered it highly probable that the vertebræ (figured in T. X, fig. 4) belonged to an extinct Lizard, distinct from the Cambridge *Raphiosaurus,* with the vertebral characters of which species we are still, therefore, unacquainted.

I have been favoured, by W. H. Bristow, Esq., with the inspection of portions, about one inch and a half in length, of the upper and lower jaws of a Lizard; the rami of the lower jaw being a third of an inch in depth, with long, slender, awl-shaped teeth, answering to those of the *Raphiosaurus.* There were five of these teeth fully formed in the portion of the upper jaw, with intervening small ones in the course of development. The portion of lower jaw had three or four irregular rows of small apertures opening on its outer side. These specimens were found in the chalk at Northfleet.

* From ῥαφίον, an awl; σαῦρος, a lizard.

† Odontography, 4to, p. 182.

‡ Transactions of the Geological Society, 2d Series, vol. vi, p. 412.

§ Ib. p. 413, pl. 39, fig. 3.

Genus, CONIOSAURUS,* *Owen.*

Species, *Coniosaurus crassidens.* (Tab. IX, figs. 13, 14, and 15.)

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 386.

Two genera of Lizards of the Cretaceous period, with procœlian cup-and-ball vertebræ, similar in size and form to those of the series figured and described in the 'Geological Transactions,' vol. vi, 2d ser., pl. 39, fig. 3, are now no longer hypothetical, but have been satisfactorily established by the discovery of portions of jaws and teeth associated with such vertebræ. The first of these specimens, which discloses a small extinct Lacertian, distinct from *Raphiosaurus,* and characteristic of the chalk formation, was obtained from the Middle Chalk at Clayton, Sussex, and forms part of the choice and instructive collection of HENRY CATT, Esq., of Brighton. It is figured in T. IX, figs. 14 and 15, and a group of vertebræ of apparently the same species is represented in fig. 13.

These vertebræ are represented of the natural size. Like those first figured in the 'Geological Transactions,' tom. cit., pl. 39, they present an anterior concavity or cup, and a posterior ball upon the bodies for their reciprocal articulation; and a tubercle is developed from each side of the vertebral body near its anterior end, for the articulation of the rib. The non-articular surface of the vertebra is smooth; its under part is concave in the axis of the body, convex transversely. On the very probable supposition, however, that the vertebræ in fig. 14 belonged to the same animal as the jaw which is imbedded in the same portion of chalk, such vertebræ must be smaller in proportion to the head than in the extinct species of Lacertine Saurian, T. X, fig. 1, likewise from the chalk, and to which there will be adduced reasons for believing that the fine specimen, in the collection of Sir P. de M. Grey Egerton, Bart. (ib. fig. 4), belongs. The fossil jaw and teeth in fig. 14 determine the distinctness of the *Coniosaurus* from the above-named fossil, as well as from all known recent Lizards.

The dentary bone contains from eighteen to twenty teeth; the anterior five or six teeth are slender, slightly recurved, pointed, or laniariform; the rest progressively increase in thickness as they are placed further back; expanding above the neck, slightly compressed laterally, most convex inwardly, with an anterior border, which is more prominent and curved than the posterior one: the anterior margin is further characterised by a longitudinal groove on its outer side. Some of the posterior teeth show a slight longitudinal indent near the posterior obtuse border; the last molar is smaller and more obtuse than the others. The enamel is very finely wrinkled. The teeth are closely and rather obliquely arranged; the long simple roots are anchylosed to the bottom of the shallow alveolar groove, and to the inner side of the outer wall,

* Κόνις, ιος, chalk; σαῦρος, lizard.

and their excavations indicate the usual mode of succession and displacement: a few alternate teeth have been shed.

The mode of attachment more resembles that which characterises the teeth in *Lacerta* proper and other "cœlodont" genera of the Lacertian tribe; but in the number, proportions, and general shape of the teeth, the present species more resembles some of the Iguanian tribe. The anterior coronal groove is continued to the anterior margin of the crown, which it slightly indents in the larger teeth; but this is the only approach to that complex structure which characterises the teeth of the typical *Iguanidæ*. Fig. 14 *a* is a magnified view of the crown of one of the anterior teeth; and fig. 15 *a'* of one of the posterior teeth.

There is no existing species of the Iguanian or other herbivorous family, nor of any of the 'pleurodont' Saurians, with which the present chalk-fossil is identical; nor can I refer it to any of the established genera of *Lacertilia*. The absence of the cranium and bones of the extremities, does not allow of any closer comparison with the Monitors, Iguanas, or Scinks; but the characters of the teeth justify the consideration of the fossil as the type of a hitherto undescribed genus and species, which I therefore propose to call *Coniosaurus crassidens*, or the thick-toothed Lizard of the Chalk formation.

The specimens represented in figs. 13, 14, and 15, are from the Clayton chalk-pit near Brighton: a smaller portion of a lower jaw and a few teeth have been obtained by Mr. Dixon from the Washington chalk-pit near Worthing: and vertebræ have been found by Mr. Catt in the upper chalk near Falmer, during the cutting of the railroad from Brighton to Lewes. These are the only specimens of the genus and species that have yet been discovered.

Genus, DOLICHOSAURUS,* *Owen.*

Dixon's 'Geology of Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 388.

Species, *Dolichosaurus longicollis.* (Tab. X, figs. 1, 2, 3, and 4.)

My esteemed friend the late Frederic Dixon, Esq., F.G.S., in the course of his indefatigable inquiries respecting the fossils of the cretaceous period, obtained such information relative to the unique specimen of the mutilated head and anterior thirty six vertebræ of the fossil Lizard from the lower chalk of Kent, in the admirable collection of Mrs. Smith of Tunbridge Wells, figured in T. X, fig. 1, as left no doubt in his mind that it formed part of the same skeleton with the chain of posterior abdominal and sacral vertebræ in the collection of Sir P. de M. Grey Egerton, Bart., M.P., F.G.S., and which is figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39; and in the present work at T. X, fig. 4.

* Δολῖχος, long, σαυρος, lizard.

Both specimens are from the same quarry or pit at Burham, in Kent, were found at the same time, and there is good reason to suppose in the same block of chalk. It appears, however, that they were disposed of by the quarrymen to different persons, and ultimately found their way to the two collections of which they are now respectively the ornaments.

Assuming, then, the two groups of vertebræ to have belonged to the same skeleton, and the conformity in shape and size of the vertebræ and ribs favours the conclusion which Mr. Dixon had drawn from the historical evidence, we may then enumerate fifty-seven vertebræ between the skull and the pelvis, supposing that none have been lost between the end of the specimen in T. X, fig. 1, and the beginning of that in T. X, fig. 4. Amongst existing Lizards this number of abdominal (cervical and dorsal) vertebræ is equalled only by those snake-like species (*Pseudopus, Bipes, Ophisaurus*) which seem to make the transition from the Lacertian to the Ophidian reptiles: but not any of such genera manifest so well-developed a humerus and scapular arch as are indicated in T. X, fig. 1, at 51 and 53, or so complete a sacrum and pelvic bones as are shown in fig. 4, at 62 and 63. Of those existing Lacertians which had the hinder extremities as well developed as in the extinct species under consideration, the greatest recorded number of vertebræ between the skull and the sacrum is forty-one.*

Although the evidence relating to the discovery of the specimens (fig. 4 and fig. 1, T. X) is such as to lead me to deem it highly probable that they form the anterior and posterior moieties of the backbone of the same individual; yet, as it does not amount to absolute demonstration, the characters of the Saurian in question must for the present be rigorously deduced from those parts which are unaffected by such uncertainty. In this fit condition for scientific comparison must be regarded the fragment of skull, and the chain of thirty-six vertebræ imbedded in one block of chalk, and represented in T. X, fig. 1. The most cautious and sceptical Palæontologist must admit, after scrupulous examination of the specimen, that the jaws and the portion of vertebral column, which are accurately figured in the plate, have belonged to one and the same animal, having been subject to no greater amount of dislocation than is represented at the twenty-fifth vertebra for example, and in the position of some of the ribs. Viewing the slight extent of displacement of any of these parts in the fossil, it is very improbable that the scapular arch (51) should have been subjected to any considerably greater degree of displacement; and taking, also, into consideration the gradual diminution of the vertebræ, as they extend forwards from the place of the scapular arch in the fossil, at the eighteenth or twentieth vertebræ, to the cranium, and the remarkable and striking difference in the shape and size of the pleurapophyses (vertebral ribs, *pl.*, *pl.*) in those anterior vertebræ, I am led to conclude that the position of the remains of the scapular arch (51) in the fossil was, in relation to the vertebral

* According to the table in Cuvier, Leçons d'Anat. Comp. i (1836), p. 221, *e.g.* in the *Scincus ocellatus*.

column, its true position in the skeleton of the living reptile, and that the vertebræ anterior to it answer to those which are called cervical by Cuvier, in the existing lizards which have four well-developed extremities.

The artificial character of the 'cervical' vertebræ of anatomy is more obvious in the Lacertine Sauria than in most other vertebrates. Cuvier, who has assigned the precise number of such vertebræ to several species of Lacertians, in his 'Table of the Vertebræ of Reptiles,'* does not define their characters. He merely observes that "they have inferior crests like the anterior dorsal vertebræ."†

With regard to the Monitor (*Varanus*) Cuvier affirms, in another work,‡ that the "inferior crest distinguishes the cervical from the dorsal vertebræ;" but he admits that the first three of these dorsal vertebræ have an inferior tubercle. Proceeding next to speak of the American Monitor (*Monitor* proper, or *Tejus*) he says,—"Les vertèbres cervicales, déterminées par les fausses côtes antérieures, sont au nombre de huit, c'est-à-dire qu'il y a six paires de ces fausses côtes."§ This number of so-defined cervicals is found in the Iguanians, Basiliscs, true Lizards, Geckos, Anolises, Agamians and Stellios. But Cuvier admits that two if not three of the last of these cervical vertebræ, although their false ribs (pleurapophyses) do not reach the sternum, are embraced by the scapular arch, and concur in the formation of the chest: if these be accordingly subtracted, the number of cervicals will be reduced, Cuvier says, to five. In the 'Table of Vertebræ' above cited, only four cervicals are allowed to the Iguana, Basilisc, the banded Gecko, Anolis, Agama, and the Levantine Stellio. There is a difference, however, in the number assigned to some of these species in the table in the 'Ossemens Fossiles.'‖ But all these discrepances depend on the inconsistent characters that hitherto have been assigned to the cervical vertebræ of Lizards.

Recognising the artificial nature of such a group of vertebræ, I believe that their character, which must needs be arbitrary, would be most easily determined, and, therefore, most convenient in its application, which should be founded on the absence of sternal ribs (hæmapophyses): according to which character the vertebra that first was joined to the sternum by sternal ribs would be reckoned as the first "dorsal," and all anterior to it as "cervical vertebræ." This arbitrary character would agree with that by which the cervical vertebræ are, in point of fact, defined in the human subject and mammalia generally.

In the fossil Lacertian, however, which forms the more immediate subject of this description, there is no indication of a junction of the vertebral rib (pleurapophysis) by a sternal rib (hæmapophysis) with a sternum (hæmal spine), and I can only compare the cervical region of the spine with that in existing Lacertians, in so far as relates to

* Leçons d'Anat. Comp. i, (1835,) p. 220.
† Ib. p. 215.
‡ Ossemens Fossiles, 4to, v, pt. ii, p. 284.
§ Ib. p. 285.
‖ Tom. cit. p. 288.

the vertebræ situated between the skull and the scapular arch. The number of vertebræ so situated in modern Lacertians is usually five, and rarely exceeds six: in the *Dolichosaurus* it was seventeen. In modern Lacertians the bodies and neural arches of such cervicals are scarcely inferior in breadth to the succeeding vertebræ, and commonly surpass them in depth by reason of the largely developed inferior spinous processes. The short anterior pleurapophyses are usually thick, broad, and expanded at their extremities, or are "hatchet-shaped" (*Cyclodus, Tiliqua, Scincus*). Besides the superior number of the cervical vertebræ in the *Dolichosaurus*, they exhibit a more decided decrease of size as they approach the head: the pleurapophysis of the third or fourth vertebra is short, almost straight, and very slender: that of the eighth or ninth vertebra is also very slender, and but a little longer: those of the three succeeding vertebræ progressively, though slightly, increase in length, but the vertebral ribs do not exhibit their normal length until the seventeenth or eighteenth vertebra: the pleurapophysial character of these eighteen or twenty anterior vertebræ is much more like that of the same vertebræ in the Ophidian than in the existing Lacertian reptiles: and there is no trace of any of the vertebral ribs having supported sternal ribs, or having been attached by these to a sternum. The slender anterior ribs increase in length, however, more gradually in the *Dolichosaurus* than in Serpents.

The occipital region of the fossil skull, with the atlas and dentata, have been too much crushed to allow of their structure being accurately determined and compared: the first tolerably entire vertebra appears to be the fourth from the head: the expanded back part of the neural arch receives the contracted fore part of that arch of the fifth vertebra: the base of the neural spine is slightly expanded posteriorly. In the fifth and succeeding vertebræ, the anterior articular processes look upwards, the posterior ones downwards, and they are simple as in ordinary Lizards, but rather longer and more slender. The thin base of the neural spine extends along the middle of the summit of the entire arch; the sides of which slope downwards and outwards more gradually, i. e. do not curve outwards so suddenly as in the *Iguana* and *Cyclodus*. The short convex diapophysis (*d*) supporting the rib is developed from the side of the fore part of the centrum beneath and a little behind the anterior zygapophysis. I excavated the chalk beneath the seventh vertebra, and exposed a short compressed 'hypapophysis,' or inferior spine projecting downwards from the middle of the hinder half of the centrum. The ribs are hollow, as in the *Cyclodus** and in Ophidians. The long pleurapophyses of the twentieth and succeeding vertebræ are more compressed than in the *Iguana* and *Cyclodus*: they are less regularly or gradually curved; the comparatively straight middle portion after the first slight bend is too constant in the ribs of the fossil not to be natural: this shape of the ribs indicates the abdomen to have been

* The vertebral ribs (pleurapophyses) are probably hollow in other Lacertians, but I cite only the genus in which I have found them so in the present comparison.

more compressed, as the number of vertebræ shows it to have been longer than in the *Iguana* or *Cyclodus*. The twenty-sixth vertebra is dislocated: the two following are turned upon their side and expose the under part: here the inferior spine has disappeared: the surface is smooth, slightly punctate, gently concave lengthwise, convex transversely. Figure 2 gives a direct side view of the best-preserved ramus (the left) of the jaw: below, in outline, of the natural size; above, magnified. The extent and upward curve of the coronoid piece (31) most resembles that in the *Varanus* (Cuvier, loc. cit. pl. 16, fig. 8 *c*); but in this genus it is relatively shorter than in the *Dolichosaurus*, and in other recent Lacertians it is still shorter and more pyramidal in shape. The extent of the surangular (30), and its length behind the coronoid, are Lacertian characters: but the outer surface is divided by a longitudinal ridge or angle into an upper and a lower facet, the upper one being slightly excavated: the enamelled crowns of the last four teeth show a simple obtuse shape; they are chiefly remarkable for their small proportional size. The two dentary bones meet at an acute angle; that on the right side joins a surangular piece which is continued back to near the articular surface. Allowing a symphysis of the ordinary lacertian proportions, the length of the under jaw may be estimated to have been four centimeters (one inch seven lines), or equal to between four and five dorsal vertebræ. One of the vertical columelliform bones is preserved on the left side of the cranium.

Parallel with the eighteenth, nineteenth, and twentieth vertebræ lie the remains of a broad, thin, and flat bone (51), with a smooth emargination, and a rough or slightly granulated surface. As the broad, thin, and anteriorly emarginate scapula of the Iguana presents a similar surface, I conclude the part in the fossil marked 51 to be scapula; and the short, thick, subcylindrical, hollow bone (53), slightly twisted and expanded at both ends, to be the shaft of the humerus: it is shorter in proportion to its breadth than in the existing Lizards, and probably supported a shorter fore-arm and fore-foot; the whole limb being therefore perhaps more formed for swimming than in the Monitors and Iguanæ.

The ball-and-socket structure of the vertebræ is better adapted to sustain the body on dry land than the biconcave structure; but the modern Crocodiles, the Amblyrhynchus or marine lizard of the Gallopagos Islands, the Salamander, and even the Lepidosteus amongst fishes, prove it not to be incompatible with aquatic habits. The *Dolichosaurus*, with a procœlian type of vertebrate structure, and amongst the earliest reptiles that manifested such structure, may well have been a good swimmer and frequenter of the ancient ocean of its epoch, as well as a crawler on dry land. Although the articulations of the vertebræ must have limited if not prohibited rotation or inflection of the spine in the vertical direction, the extent of lateral flexuosity is considerable; the double curve of the fore part of the vertebral column, preserved in fig. 1, being, if not the natural one assumed in the last struggles of the dying

animal, that which the vertebral joint freely allowed in the dead carcase before it became fixed in the chalk-mud.

Assuming that the specimens fig. 1 and fig. 4, T. X, give the natural length of the neck and trunk of the *Dolichosaurus,* to which trunk the size of the anterior caudal vertebræ indicate a long and strong tail to have been appended, the progress of the long and slender *Dolichosaurus* through the water would be by flexuous and undulatory lateral movements of the entire body, like those of a water-snake or eel.

The specimen fig. 1, T. X, demonstrates that this procœlian Lizard of the cretaceous period had a smaller head and a longer, more slender and tapering neck than any known existing species of the Lacertian order of Reptiles.

The hinder moiety of the trunk-vertebræ, with part of the pelvis and root of the tail, fig. 4,—which, from the correspondence of size, shape and structure of the vertebræ, I refer to the *Dolichosaurus,* and from the evidence above given, corroborated by the disposition of the parts in the chalk-matrix, I believe to be part of the same skeleton as the anterior moiety, fig. 1, T. X—includes twenty-one abdominal, two sacral, and five caudal vertebræ. They have been exposed by the removal of the chalk from their inferior or ventral surfaces, the operation having been commenced from the opposite side of the block from that at which the exposure of the part of the skeleton in the other portion of the same block of chalk has been effected. The bodies of the vertebræ and the ribs show the same disposition and slight degree of dislocation as in the specimen. The ribs have been pressed by the weight of the surrounding chalk, as the soft parts yielded and became decomposed, close to the sides of the vertebræ, but with scarcely any further dislocation; and the vertebræ, maintaining the close articulations of their cup-and-ball surfaces, continue, with not more deviation from the straight line than a slight flexuosity, like that shown by the last six vertebræ in the moiety of the skeleton in T. X, fig. 1.

The under surfaces of the vertebræ exhibit the same smooth, imperforate, longitudinally concave, transversely convex surfaces, as in the anterior dorsals of the last-described specimen: as in that specimen, also, they are longer in proportion to their breadth than in the Monitor (*Varanus ?*) figured by Cuvier,* or than in the *Iguana, Cyclodus* and *Tiliqua :* the diapophyses rise by a shorter base than in the *Iguana:* in an Australian *Tiliqua* I find the under surface of the centrum with two vascular perforations towards its fore part, which are not present in the *Dolichosaurus,* nor in many of the existing Lacertians. Each diapophysis forms a short rounded tubercle, immediately below the base of the anterior zygapophysis; and the simple, slightly expanded head of the rib is excavated to fit the tubercle. In the degree of compression and expansion of the proximal portions of the ribs, and in their curvature, the present precisely corresponds with the preceding portion of the skeleton of the *Dolichosaurus ;* and it is

* Ossem. Foss., v, pt. ii, pl. 17, fig. 23.

obvious that the natural form of the abdomen must have been deep and narrow, like that of the Water-Snakes (*Hydrophides*).

The length of the last two abdominal vertebræ slightly decreases: a short, slender, nearly straight and pointed pleurapophysis projects outwards from the diapophysis of the last abdominal (lumbar) vertebra with which it has become anchylosed. The pleurapophyses of the next two vertebræ are equally confluent with the diapophyses, but are rather longer and much thicker than those of the preceding vertebra: they are also slightly expanded and truncate at their ends; they determine by these proportions the 'sacral vertebræ,' which thus agree in number, as in general structure, in the *Dolichosaurus* with those in existing Lacertians.

Part of the bodies of the two sacral vertebræ has been destroyed, but evident traces of the persistent cup-and-ball articulation between them remain. In the Scincoids the bodies of the sacral vertebræ become anchylosed together. The extremities of the sacral pleurapophyses come into contact in the *Dolichosaurus*, but do not coalesce: the second sacral vertebra presents a ball to the first caudal, as in existing Lacertians, not a cup, as in the modern *Crocodilia*. On the right side of the specimen the hinder half of the iliac bone extends backwards, projecting freely a short way behind the second sacral pleurapophysis, as in some modern Lacertians (*Cyclodus*, e. g.). On the left side a part of the ilium is preserved, which extends to the acetabulum. A portion of the expanded ischium is likewise preserved, and the distal half of the left femur extends back in a right line from the position of the hip-joint. The length of the entire femur could not have exceeded three centimeters, or fourteen lines; it thus agrees in its relative shortness with the humerus in fig. 1, 53, and accords with the idea that the *Dolichosaurus* was more aquatic in its habits than the modern Lacertians, most of which have longer proportional humeri and femora. The femur of the *Dolichosaurus* had a medullary cavity. The under surface of the first two caudal vertebræ is impressed by a median, longitudinal, shallow canal, bounded by two slight ridges, diverging posteriorly in the second caudal to the tubercles (hypapophyses) that have supported the hæmal arch; these tubercles are close to the posterior articulation. A part of the spine of this hæmal arch is preserved nearly in its true position.

The foregoing comparisons show that all the general characters of the Lacertian type of the vertebrate skeleton are presented by the *Dolichosaurus*: they are most modified in the cervical region, where the Ophidian type is rather followed in the number and size of the vertebræ, and in the size and shape of the ribs: a less decided approach, but one still indicating an affinity to the Ophidians, is made by the unusual length of the slender trunk, which includes, from the skull to the sacrum, not fewer than fifty-seven vertebræ, and is not less than eighteen inches in length. The smallness of the head accords with the long and slender proportions of the neck, and must have added to the snake-like appearance of this early example of procœlian lizard. But the complete and typically Lacertian organisation of the scapular and pelvic arches, and

of their locomotive appendages, prove that the *Dolichosaurus* was more strictly a lacertine Saurian than the existing genera, *Pseudopus, Bipes* and *Ophisaurus,* which effect the transition from the Lizards to the Snakes.

Tribe, NATANTIA.

Genus, MOSASAURUS.

The history of the discovery by Major Drouin, in 1766, of the gigantic marine lizard called by Conybeare *Mosasaurus,* together with an account of the nature of the formation in which its remains occur, are fully given by Cuvier, in his 'Recherches sur les Ossemens Fossiles,' tom. v, pt. ii, pp. 310—320. The largest species of *Mosasaurus* is calculated to have been at least twenty-five feet in length, and derives its name from the locality on the banks of the Meuse, near Maestricht, where the newer cretaceous deposits occur in which its remains were found. The finest and most perfect skull of the animal was discovered in the quarries at St. Peter's Mount. Camper saw it in 1785, in the house of the Rev. Dr. Goddin, canon of the chapter of Maestricht, and writes:—"In this the greater part of both the upper and under maxillary bones is entire, and a bone, with small teeth, belonging to the palate; by which it appears, the animal had not only teeth in the jaw-bones, but also in the throat, as several fishes have, but which are never found in the mouth of crocodiles;"* and Camper naively expresses his surprise that notwithstanding all his endeavours to convince his friends, he "never could prevail upon them to adopt his opinion, that these bones belonged to the physeteres or respiring fishes." In fact, neither the physeter nor any other cetacean or respiring fish, have teeth on the palate any more than the crocodiles. M. Adrien Camper, the son of the great anatomist, first pointed out the affinities of the Mosasaurus to the *Monitors* and *Iguana,*† in which latter genus, as in *Amblyrhynchus,* small teeth are present on the same bones, viz., the pterygoid, in which they occur in the Mosasaurus. The large fossil skull of the Mosasaurus was yielded up by the Canon Goddin to the French army, after the capture of Maestricht by the forces of the Republic in 1795, and it was transported to the Museum of the Garden of Plants at Paris, where it still remains. M. Faujas St. Fond, who, in his capacity as Commissary for the Sciences of the "Army of the North," transacted the transfer of the famous specimen, gives the following account of its discovery:—

* Philosophical Transactions, 1786, p. 444.

† In a letter to M. Cuvier, in the 'Bulletin de la Société Philomathique,' Fructidor, An. viii (1790); and in the 'Journal de Physique,' Vendemiaire, An. ix (1791). See also his 'Mémoire sur quelques parties moins connues du squelette des Sauriens Fossiles de Maestricht,' in the 'Annales du Muséum d'Hist. Nat.,' tom. xix (1812), p. 215.

"In one of the great galleries or subterraneous quarries in which the cretaceous stone of St. Peter's Mount is worked, about five hundred paces from the entrance, and ninety feet below the surface, the quarry-men exposed part of the skull of a large animal in a block of the stone which they were engaged in detaching. On this discovery they suspended their work, and went to inform Dr. Hoffmann, surgeon to the forces at Maestricht, who for some years had been collecting the fossils from this quarry, remunerating the workmen liberally for the discovery and preservation of them. Dr. Hoffmann, arriving at the spot, saw with extreme pleasure the indications of a magnificent specimen; he directed the operations of the men, so that they worked out the block without injury to the fossil, and he then with his own hands cleared away, by degrees, the yielding matrix, and exposed the extraordinary jaws and teeth, which have since been the subject of so many drawings,* descriptions, and discussions. This fine specimen which Hoffmann had transported with so much satisfaction to his collection, soon, however, became a source of much chagrin to him. Dr. Goddin, one of the canons of Maestricht, who owned the surface of the soil beneath which was the quarry whence the fossil had been obtained, when the fame of the specimen reached his ears, pleaded certain feudal rights in support of his claim to it. Hoffmann resisted, and the canon went to law. The whole chapter supported their reverend brother, and the decree ultimately went against the poor surgeon, who lost both his specimen and his money, for he was made to pay the costs of the action." M. Faujas St. Fond, the instrument of the more forcible and summary mode by which the French seized upon the unique specimen, moralizes in his narrative of the robbery in the following strain:—"The canon Goddin, leaving all remorse to the judges who had pronounced the iniquitous sentence, became the happy and contented possessor of this unique example of its kind. But justice, though tardy, comes at last." (!) M. Faujas then proceeds to narrate how, in the bombardment of the town, directions were given to spare the suburb in which the famous fossil was understood to be preserved; and how, after the capitulation, the French grenadiers discovered, seized, and bore off the specimen in triumph to the commissarial residence; and concludes by a pæan to the "excellent soldiers who always knew how to appreciate and respect the monuments of the arts and sciences."†

The occurrence of remains of the *Mosasaurus* in England was first noticed by, Dr. Mantell, in a work entitled 'The Geology of the South-east of England," 8vo, 1833, in which woodcuts are given at p. 146, of a dorsal vertebræ, and of two caudal vertebræ, which were found in the upper (?) chalk, near Lewes. The body of the dorsal vertebra is said to be "about two inches long, and 1·4 inch high;" and the

* First by Buchoz, in his 'Dons de la Nature,' tab. 68; then by Faujas St. Fond, in plate iv of his 'Histoire Naturelle de la Montagne de St. Pierre;' afterwards by Cuvier, in his 'Ossemens Fossiles,' tom. v, pt. ii, pl. xviii; copied by Buckland in the 'Bridgewater Treatise,' pl. 20.

† Tom. cit., p. 62.

mutilated body of a vertebra of these dimensions, together with the two caudal vertebræ, form part of that collection which was sold by Dr. Mantell to the British Museum. No proof is given that these vertebræ belong to the same species as the *Mosasaurus Hoffmanni:* the dorsal vertebræ of the great Mosasaurus of Maestricht are more than double the size of the one above cited, which, in the complete anchylosis of the neural arch, would seem to have belonged to a mature individual of that cold-blooded genus.

Subsequent discoveries of Mosasaurian Fossils in the English cretaceous deposits have enabled the comparison with the specific characters of the *Mosasaurus* of Maestricht, and of that from the Green-sand of North America, to be carried out satisfactorily, especially in reference to the modifications of the teeth.

MOSASAURUS GRACILIS, *Owen.* Tab. VIII, figs. 1, 2, and 3. Tab. IX, figs. 1, 2, 3, 4, and 5.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex.' T. XXXIX.

CUVIER,* in his account of the great *Mosasaurus* of Maëstricht, which is entered in the catalogues of M. v. Meyer and M. Pictet, under the synonyms *M. Camperi* and *M. Hoffmanni*, states that "all the teeth are pyramidal, a little curved, with their external surface flat ('plane') and divided by two sharp ridges from the internal surface, which is round or rather semi-conical." Messrs. Von Meyer† and Pictet‡ repeat Cuvier's description of the external characters of the crowns of the teeth; the one says, "ihre Aussenseite ist eben"—their outer side is flat or level; the other, "leur face externe est plane." My description§ of the teeth of the Maestricht Mosasaurus, in which it is stated that "their outer side is nearly plane, or slightly convex," was founded on an examination of the magnificent fossil skull in the Parisian Museum, the original of Cuvier's description;—and the contour of the base of the crown of a maxillary tooth of the *Mosasaurus Hoffmanni* given in T. IX*A*, fig. 7, is taken by accurate admeasurement from a perfect specimen from the Maëstricht chalk: the enamelled crown of this tooth was two inches (five centimeters) in length; the rest of the tooth was formed by the enlarged coarse osseous fang; the total length of the tooth being four inches ten lines (twelve centimeters and a half). Dr. A. Goldfuss, in his highly interesting and instructive description|| of the skull and teeth of the *Mosasaurus Maximiliani,* accurately describes and figures the finely dentated character of the two opposite longitudinal ridges of the crown; but the feeble indications of angles observable in some of the

* Annales. du Muséum d'Hist. Nat., xii, 1808. Ossemens Fossiles, 4to, v, pt. ii, p. 322.

† Palæologica, p. 219.

‡ Traité élémentaire de Paléontologie, ii, p. 63.

§ Odontography, 4to, p. 258.

|| Nova Acta Acad. Nat. Cur., t. xxi, p. 175.

teeth, those of the upper jaw chiefly, of the *Mosasaurus Hoffmanni*, do not bear out the term "polygonal" which he applies to the crowns of the teeth of that species, as well as to those of his *Mosasaurus Maximiliani;* still less can I find these angles so constant and regular as to divide the outer surface of the crown into five, and the inner surface into seven facets; nor have I seen in any maxillary or mandibular tooth of *Mosasaurus Hoffmanni* that near equality of extent and convexity between the inner and outer surfaces of the crown, which Dr. A. Goldfuss describes (p. 178) and figures in Tab. 9, fig. 4, of the memoir above cited. If that figure accurately represents a maxillary tooth of the same species of *Mosasaurus* as the one described by Cuvier and recorded by V. Meyer and Pictet under the name of *M. Camperi* and *Hoffmanni;* and if the outer surface of the crown is ever flat or level, the range of variety between the two extremes of flatness and convexity is greater than I have yet found in any of the equally well-marked forms of teeth in other fossil reptiles.

The teeth in the specimens of upper and lower jaw of the species of Mosasaur from the chalk-pit at Offham, Sussex, now in the Museum of Henry Catt, Esq., of Brighton, and figured of the natural size in T. IX, fig. 1 and 1*a*, equally differ from the typical form of tooth of the *Mosasaurus Hoffmanni*, and from those of the *Mosasaurus Maximiliani*, T. IX*A*, fig. 8: the outer surface of the crowns of the mandibular teeth of *Mosasaurus gracilis* are more convex than those of *Mos. Hoffmanni*, and are less convex than those of *Mos. Maximiliani:* not any of the teeth of *Mosasaurus gracilis* present that angular disposition of the enamel which gives the polygonal form to the pyramidal crowns of the teeth of the *Mos. Maximiliani.* The lower jaw (T. IX, fig. 1) is more slender, less deep in proportion to its length, than in the great Maestricht Mosasaur, and the hinder teeth are relatively smaller and closer together; I have proposed, therefore, to indicate the species by the name of *Mosasaurus gracilis.* The general form of the crown of the teeth in *Mos. gracilis* is shown at *a*, *b*, and *c*, fig. 1; an exact contour of the crown a little above its base is given at fig. 9, T. IX*A*. The smooth and polished enamel; the inequality of the outer and inner sides of the crown, such as it is; the implanted fang of the tooth thickly coated by a coarse osseous cement; the general anchylosis of the fang to the bony walls of the socket, which rise in a pyramidal form from alveolar border of the jaw; all manifest the peculiar generic characters of the great acrodont marine lizard, *Mosasaurus.* The maturity of the individual from which the present specimen (fig. 1) has been derived, cannot be inferred from the solidification and complete development of the anchylosed fangs of the teeth in a class of animals in which those organs are repeatedly shed and renewed: the worn-out teeth, in course of displacement, of the young crocodile, with their alveoli, present in miniature all the senile characters of the corresponding teeth of the mature and aged animal. If, however, the specimen of Mosasaur in question should be adult, it would derive a well-marked specific character from its diminutive size as compared with the *Mosasaurus Hoffmanni* or *Mos. Maximiliani;* being only one third the size of the latter,

and one fourth that of the former species. But the characters of immaturity are not manifested by the cold-blooded animals in their osseous and dental systems as they are in the warm-blooded and higher organised mammalia.*

In all the teeth of the *Mosasaurus gracilis* in which the crown is broken, the remains of the pulp-cavity are exposed in the centre of its base: but the immaturity of the specimen is not demonstrated by this character; for, in the largest sized teeth of the *Mosasaurus Hoffmanni*, even in one with a completely developed fang, measuring with the crown nearly five inches in length, I have found a pulp-cavity extending from the base of the crown into the expanded fang, but becoming almost obliterated at the base of the fang. The cast of the crown of a still larger tooth of a Mosasaurus from the green-sand of New Jersey, U.S., also shows the remains of a pulp-cavity at its base. This cavity becomes filled in the fossil specimens with the matrix, which is usually chalk; but sometimes the cavity, like the air-chambers of polythalamous shells, is filled with silex.

The number of teeth in each ramus of the lower jaw of *Mosasaurus gracilis* seems not to have exceeded twelve. In *Mosasaurus Maximiliani* they are reckoned at eleven;† in *Mosasaurus Hoffmanni* at fourteen; and in this species they are placed closer together than in the *Mos. gracilis*, as may be seen by comparing figure 1 of T. IX, with that of the lower jaw given by Camper in the 'Philosophical Transactions' for 1786, tab. xvi, which is copied by Faujas St. Fond, in pl. vi, of his 'Histoire de la Montagne de St. Pierre.'‡ The posterior teeth are rather smaller than the others in *Mosasaurus gracilis.* At the fore part of the jaw the implanted and anchylosed base of the teeth extends through about half the vertical diameter of the jaw; at the posterior part of the series the fangs sink into one third or one fourth the depth of the jaw. The canal, which, as in the crocodile, extends below and along the inner side of the bases of the sockets and anchylosed fangs, is shown, filled by chalk, at *d*, fig. 1. Traces of the vascular foramina along the outer side of the jaw are visible in the right dentary piece, the outer side of which is exposed: the "splenial" ("opercular," Cuvier,) element is shown at fig. 1, on the left ramus.

In the portion of the left superior maxillary bone (T. IX, fig. 1 *a*) all the teeth are, unluckily, too much broken or abraded to give an idea of the precise form of their crowns; they are rather more compressed at their base than in *Mosasaurus Hoffmanni:* the posterior ridge is much less developed, and the whole of the posterior longitudinally concave border is more transversely convex than in *Mosasaurus Hoffmanni* or *Mos. Maximiliani.* There is as little indication of the angular or polygonal

* Dr. Goldfuss infers the maturity of his *Mosasaurus Maximiliani* from the characters, of which the inadequacy is explained above. "Die vollständige Verknöcherung aller Theile, so wie die häufige bemerkbare Aussfullung der Zähne beweisen, dass das Individuum seine vollständige Ausbildung und mit dieser nur die halbe länge des *Mosasaurus Hoffmanni* erreicht hatte." (Loc. cit., p. 177.)

† Goldfuss, loc. cit. p. 178. ‡ Cuvier, loc. cit. p. 320.

structure in these teeth as in those of the lower jaw; but the enamel shows some longitudinal striations.

All the vertebræ of the *Mosasaurus*, according to Cuvier, are concave at the fore part, convex at the hind part of their bodies; the convexity and concavity being greatest on the anterior vertebræ. The foremost of these are characterised by an inferior process or "hypapophysis," developed from the middle of the lower surface of the centrum: they have two transverse and four articular processes, and a long compressed upper or neural spine. The centrum is longer than it is broad, and broader than it is high; the terminal articular surfaces are transversely oval or reniform. Such are the characters of the last cervical or first dorsal vertebræ. The middle dorsal vertebræ are like these, but have no hypapophysis. Then follow vertebræ which have no articular or oblique processes (zygapophyses), but have longer and flatter transverse processes (diapophyses), and terminal articular surfaces of a pentangular form, or of a triangular form with the base downwards (see T. VIII, fig. 5). Next come vertebræ with diapophyses and a pair of inferior processes (hypapophyses) for the articulation of chevron-bones (hæmapophyses); afterwards vertebræ without transverse processes and with large anchylosed chevron-bones (hæmapophyses); and finally vertebræ devoid of all processes whatever.

The vertebræ discovered in the Kentish Chalk, with the jaws and teeth above described, and of corresponding proportions to those parts which we observe in the vertebræ of the *Mosasaurus Hoffmanni*, present all the generic vertebral characters of that Lacertian genus, and correspond with the third and sixth kind, or with the posterior dorsal and the anterior caudal vertebræ, as defined by Cuvier. But the terminal articulations of the centrum of the dorsal vertebræ of *Mosasaurus gracilis* present a full oval (not elliptical) form, the long axis of which is vertical and the great end downwards (T. IX, fig. 4). The length of the centrum (*ib.*, fig. 3), which is three centimeters and a half, or one inch and five lines, exceeds the breadth; but this is equalled by the height of the centrum. The diapophyses in fig. 2, *d*, are broken away; in fig. 3 it is uncertain whether the surface be a fractured one, or whether it is a natural cavity for the rib; the analogy of *Mosasaurus Hoffmanni* favours the former view of it. The neural arch (fig. 3, *n*) is anchylosed to the centrum, as in the larger species of *Mosasaurus*. I can perceive only a feeble indication of zygapophyses, which shows that the vertebra (figs. 2 and 3) comes from the posterior region of the back. The neural canal (fig. 4, *n*) is small and triangular; a sharp longitudinal ridge rises from the middle of its floor, and on each side of this there is a vascular canal descending vertically into the substance of the centrum; this substance presents a coarse fibro-cancellous texture; the areolæ extended longitudinally, and decreasing much in size at the ends of the centrum. The outer surface of the vertebra is smooth; the margins of the anterior articular concavity are sharp.

The vertebra (fig. 2) shows, by the lower position of the diapophysis (*d*), that it

comes from a more posterior position of the spine than that represented in fig. 3. Fig. 5 gives a view of a caudal vertebra, which demonstrates another Mosasaurian character in the anchylosis of the hæmapophyses or chevron-bones to the centrum, as in the posterior caudal vertebræ of *Mosasaurus Hoffmanni;* but the hæmal canal (fig. 4, *e*) is relatively wider, and the entire centrum is much longer than in the corresponding kind of vertebra figured by Cuvier* or by Faujas St. Fond.†

Three views of the body of a vertebra of the *Mosasaurus gracilis*, discovered by the Rev. H. Hooper, M.A., distinguished by his geological researches in the neighbourhood of Lewes and Brighton, are given in Mr. Dixon's work above cited, Tab. XXXIX, figs. 5, 6, & 7. This specimen is from the Sotheram Chalk-pit, near Lewes.

From the genus *Leiodon*‡ (T. IX*A*, fig. 5**) the *Mosasaurus gracilis* (Ib. fig. 9) differs, like the *Mosasaurus Hoffmanni* (Ib. fig. 7), in the inequality of the two sides of the crown of the teeth, which are bounded or divided by the anterior and posterior ridges. The *Mosasaurus Maximiliani* (Ib. fig. 8) differs from the genus *Leiodon* in the polygonal character of the crowns of the teeth.

The interest which must be excited in the Naturalist and Palæontologist by an extinct Saurian, essentially organised according to the Lacertian type, but developed on a scale surpassing that of the largest existing Crocodiles, and especially modified, as it seems, for aquatic life, leads me to believe, that any additional facts tending to complete its restoration will here be acceptable, although they may not have been afforded by fossils from British strata. In the formations of the Cretaceous Period in North America, answering in mineralogical characters to our Green-sands, though probably contemporaneous with the newest chalk deposits of Europe, many fine examples of *Mosasaurus*, of the species called by Goldfuss, *Mos. Maximiliani*, have been found, and the discovery affords a highly instructive instance of the coexistence of particular forms of fossil Reptilia in remote parts of the earth, at the same geological epoch. In a series of remains of the *Mosasaurus Maximiliani*, from a Green-sand formation at New Jersey, United States, kindly submitted to my examination by Professor Henry Rogers, of Pennsylvania, I detected the basioccipital bone of the cranium, which gave additional evidence of the Lacertian affinities of the *Mosasaurus*, and new proof of the Cuvierian law of correlation of organic structures. This basioccipital bone, which is figured in the 'Quarterly Journal of the Geological Society,' November, 1849, pl. x, fig. 5, was three inches and a half in length, and four inches nine lines in extreme breadth. It resembled the centrum of the "vertebra dentata" of the *Crocodilia*, in being convex behind and flattened in front. The convexity formed the inferior and major part of the occipital condyle, which must have been reniform, the angles being superior, and formed by the

* Cuvier, loc. cit., pl. xix, fig. 6, *A*, *B*. † Loc. cit., pl. viii.

‡ Odontography, 4to, p. 261, pl. 72, figs. 1 and 2.

exoccipitals. The rough sutural surfaces for the articulation of these elements were divided by a deep and narrow channel, which gradually expanded towards the condyle. The anterior flat vertical articular surface of the basioccipital was smooth, indicative of a persistent harmonia between it and the basisphenoid, analogous to that which exists between the centrum of the axis and the odontoid process. Two very thick and short exogenous processes (hypapophyses) diverge from the under part of the anterior half of the basioccipital, and terminate in oblique and slightly convex surfaces, irregularly pitted; they resemble the hypapophyses sent off from the basisphenoid in the great Monitor (*Varanus*), against which the pterygoids abut. This form and structure of the basioccipital of the Mosasaurus harmonizes with the other indications of its Lacertian affinities. The basi-occipital in the *Crocodilia* sends down a single hypapophysis.

No part of the organisation of the *Mosasaurus* is so little known as that of the locomotive extremities. Cuvier gives copies of drawings which had been transmitted to him of a portion of the scapula,* clavicle,† and coracoid,‡ of a portion of a long bone, which he likens to the cubitus of a Monitor,§ and of an os pubis,|| all of which he believes to have belonged to the *Mosasaurus*.

The portion of the ulna would indicate, Cuvier remarks, that the *Mosasaurus* had moderately elevated extremities;¶ but he adds that "the bones of the fore and hind feet, so far as they are known, would seem, on the contrary, to have belonged to a kind of contracted fin, like that in the dolphin or *Plesiosaur*.** He, however, figures two bones comparable with the two principal bones of the carpus of the Crocodile,†† and which one would scarcely expect to be associated with metacarpals and phalanges like those of the *Enaliosaurs*. And if the ungual phalanx, figured in pl. xx, fig. 21, of the 'Ossemen's Fossiles,' be rightly attributed to the *Mosasaurus*, it determines the question in the negative, as to whether that Lacertian reptile had plesiosaurian paddles; the phalanx in question much resembles that in the British Museum (No. 384, Mantellian Catalogue), which has been described as "The Horn of the *Iguanodon*." The phalanx represented in Pl. xx, fig. 5, of the same work, with almost flat articular ends, must have belonged to a natatory form of foot; but as large Chelonians were associated with the *Mosasaurus* in the Maestricht beds, it would be rash to conclude that this phalanx absolutely belonged to the *Mosasaurus*. Cuvier, in fact, sums up by admitting the hesitation which he feels in offering his conjectures as to the nature of the extremities of the *Mosasaurus*, which were founded on the inspection of drawings

* Ossemen's Fossiles, tom. v, pt. 2, 4to, pl. xix, fig. 9. † Ib., fig. 14.

‡ Ib., fig. 15. § Ib., pl. xx, fig. 24. || Ib., pl. xix, fig. 10.

¶ "Il annoncerait que ses extremités étaient assez élevées." (Ib., p. 336.)

** "Les os des mains et des pieds, autant qu'on les connaît, sembleraient au contraire avoir appartenu à des espèces de nageoires assez contractées, et plus ou moins semblables à celles des dauphins ou des plésiosaurus." (Ib. p. 386.)

†† Ib., pl. xx, figs. 4 and 5.

only, for he says the immediate comparison of the bones themselves would hardly suffice, so great is the diversity and so small the precision of the forms of those bones in reptiles.*

M. Pictet, in the second volume of his 'Traité Elémentaire de Paléontologie,' 8vo., 1845, terminates his brief summary of the characters of the *Mosasaurus*, by stating:—"Les membres paraissent avoir été terminés par des nageoires aplaties," (p. 62.)

In the collection of Saurian fossils submitted to me by Professor Henry Rogers were some bones of the extremities, showing the Lacertian type of structure, and agreeing in colour, petrified condition, and proportional size with the vertebræ and teeth of the *Mosasaurus* from the same Green-sand formation. They were too large to be attributed to the Crocodilian species indicated by the vertebræ from the same formation. I subjoin, therefore, a brief description of these interesting fossils which appear to me to throw additional light on the structure of the locomotive organs of the *Mosasaurus*.

The first of these bones gave the following dimensions:—

	Feet.	Inches.
Extreme length	2	8
Extreme breadth of the broader end	0	8
Breadth of narrower end of the same bone (imperfect)	0	$4\frac{1}{2}$

The best preserved extremity of this long bone is expanded and subcompressed, like the lower end of the fibula of the *Varanus*, one part of this extremity being produced into an obtuse angle. The extremity is smooth, slightly concave transversely on one side, more irregular on the opposite side, with a thick prominent border opposite to the produced angle. The shaft of the bone has an irregular full, oval, transverse section with dense walls of concentric plates of bone, eight or nine lines thick, surrounding a medullary cavity, one inch nine lines in diameter. The shaft is very slightly bent. The opposite extremity which gradually expands, preserving the general form of the shaft, exhibits a strong longitudinal ridge of six inches in extent, but which subsides before it reaches the articular end. Only a portion of this end is preserved, which is slightly and irregularly convex.

The second long bone of the extremity yields the following dimensions:—

	Feet.	Inches.
Extreme length	2	5
Breadth round the upper (?) articulating surface	0	$4\frac{1}{2}$
Depth of articulating surface	0	$3\frac{1}{4}$
Breadth of lower (?) end (imperfect)	0	3

This bone, therefore, equals in length the preceding, but becomes more attenuated in the middle than any of the long bones in the existing *Saurians*; one extremity is

* Loc. cit., p. 357.

compressed, and terminates in a slightly convex, thick, smooth articular border. Nine or ten inches below this, the shaft, slightly increasing in breadth and decreasing in thickness, presents a thick, rough, and prominent ridge, three inches and a half in length, apparently for the attachment of some strong muscle; behind this ridge the shaft contracts to a diameter of one inch nine lines, and to a circumference of four inches six lines. At ten inches from the distal end it increases in thickness, assumes a trihedral form, with one edge produced and convex, subsiding above the articular end, which is in the form of a simple convex condyle, not excavated for a trochlear joint in the middle, but with an irregular branched impression or smooth groove at that part: the articular surface extends upon the fore and the back part of the shaft, about two inches six lines from the end, contracting posteriorly, and with a convex border anteriorly above, where there is a shallow semilunar depression. There is a very deep large hemispheric pit on each side above this condyle. There is no medullary cavity in this bone.

These two long bones are more like the tibia and fibula of the larger lizards than the radius and ulna: there can be little doubt that they belong either to the leg or to the antibrachium, but they differ too much in shape from any of the bones of those segments in the larger lizards, with which I have been able to compare them, to encourage me to hazard a positive determination. I should be disposed to ascribe them, from their length and slenderness, to the hind leg. They are more Lacertian than Crocodilian in their general character; and they belong with great probability to the *Mosasaurus*.

A metacarpal or metatarsal bone of the same reptile gives the following dimensions:—

	Feet.	Inches.
Extreme length	1	8
Extreme breadth of the broader articulating surface or upper end	0	$4\frac{3}{4}$
Central depth of ditto	0	$3\frac{1}{4}$
Breadth of lower end	0	3

The proximal or upper end is suddenly expanded, with an undulated or partly convex partly concave articular surface, nearly flat, at right angles to the shaft; subtriangular with the angles rounded off, or reniform on account of the deep notch posteriorly, below which there is a depression. A ridge is continued from the shaft upon two of the angles, which gives a subhemispheric section of the shaft at six inches from the head. Here a medullary cavity nine lines in diameter is exposed. One half of the parietes of the middle third of the shaft of this bone is preserved, which shows a continuation of the medullary cavity and the development of an angular ridge from the shaft, which subsides about six inches from the distal end. This end slightly expands into a simple convex condyle, with the articular surface

irregularly grooved, and with a large deep hemispheric pit on one side above the surface, but not on the other.

The above-described long bones were taken back by Professor Rogers to America; the following specimen he liberally permitted me to retain.

A metacarpal or metatarsal bone rather larger than the preceding, with the notch at the proximal end much less deep. The angular border or ridge, continued from one of the posterior rounded angles of the articular surface, quickly subsides; that from the other angle is continued down from the middle of the shaft, giving it an oval transverse section. The fracture of the shaft, nine inches from the head of the bone, exposes an oval medullary cavity, nine lines in the long diameter. The longitudinal ridge is developed from the distal half of the bone, as in the former, and it terminates in a simple convex condyle with the grooved sculpturing upon the articular surface, and with the large deep hemispheric pit for a ligament, on one side of the trochlea, and a large shallow notch on the opposite side.

The following two bones of the toes conform to the Lacertian type, and not to that of the *Enaliosauria.* The first is a proximal phalanx of a toe of apparently the same Saurian as the bone last described. The proximal articular surface appears to have been subcircular, very slightly concave, with a few shallow pits and grooves in the middle, like those on the end of the metatarsal. The shaft gradually contracts, and becomes more convex in front than behind; it subsides into a shallow depression above the forepart of the distal trochlea, on each side of which there is a large and deep ligamentous pit. Its dimensions are as follows:

	Inches.
Extreme length	5
Breadth of upper articulating surface	$2\frac{1}{2}$
Depth of ditto	$2\frac{1}{2}$
Breadth of lower articulating surface	$1\frac{3}{4}$
Depth of ditto	2

The second specimen is a second phalanx of apparently the same toe; having an expanded, concave, proximal, articulating surface, adapted to the distal surface of the preceding bone; and terminated by an oblique broad convex trochlear articulation. Its dimensions are as follows:

	Inches.
Extreme length	$3\frac{1}{2}$
Breadth of upper articulating surface	$2\frac{1}{4}$
Depth of ditto	2
Breadth of lower articulating surface	2
Depth of ditto	$1\frac{1}{2}$

On the highly probable supposition that the above-described long bones belong to the *Mosasaurus,* they indicate the extremities of that gigantic lizard to have been

organised according to the type of the existing *Lacertilia* and not of the *Enaliosauria* or *Cetacea.* But a foot so organised for crawling on land might, nevertheless, by the webbed union of the large and long unguiculate claws, have been well adapted, like the feet of the Amblyrhynchus and Alligator, for swimming; and the modifications of the vertebral column, especially of the long and deep tail of the *Mosasaur,* clearly prove it to have been more strictly aquatic in its habits than any known existing lizard.*

The vertebra from the Chalk near Lewes (Tab. VIII, figs. 1 and 2) above alluded to, which is the subject of the cut, No. 2, p. 146, of Dr. Mantell's 'Geology of the South-East of England,' is one of those posterior dorsal or lumbar vertebræ, in which the diapophysis (*d*) arises from near the middle of the side of the centrum, and has a depressed flattened form, at its origin, instead of the thicker subcompressed form that characterises the same process in the anterior dorsal vertebræ. The specimen in question is much mutilated; both the neurapophyses, *n,* the diapophyses, *d,* and part of the left side of the centrum, are broken away; but the rarity of such evidences of the Mosasaurian genus in our English Chalk, and the historical interest attached to this, which is one of the first specimens discovered, has induced me to give an accurate figure of it in T. VIII, figs. 1 and 2, together with one of the homologous vertebræ of the Maëstricht species (figs. 4 and 5), which is preserved in the British Museum. The specimen from Lewes presents the following dimensions:—

	Inches.	Lines.
Length of the centrum	2	0
Vertical diameter of ditto	1	4
Transverse diameter of ditto	1	6
Length of the base of the neural arch	1	8

The neural arch, *n,* has completely coalesced with the centrum: it terminates behind, about four lines from the convex articular end of the centrum. The marginal circumference of that surface, fig. 2, has been worn away, but it evidently presented a more obovate and less triangular figure than in the *Mosasaurus Hoffmanni,* fig. 5. The fractured base of the diapophysis, shown at *d,* fig. 4, is situated lower than half-way down the side of the centrum.

The two caudal vertebræ (fig. 3) have been retained in natural juxtaposition in the same block of Chalk. Both the neural (*n*) and hæmal (*h*) arches have coalesced with the centrum without any trace of the primitive sutures, the antero-posterior extent of the neurapophysis is relatively shorter than in the more advanced vertebra,

* M. Hermann von Meyer, in his comprehensive and useful summary of Fossil Remains, entitled 'Palæologica,' 8vo, 1832, classifies the *Mosasaurus* with the *Plesiosaurus,* in the Order of *Sauria,* characterised by fins. ("Saurier mit flossartigen Gliedmassen," p. 201.)

as is shown by fig. 6 as compared with fig. 4, and by the following admeasurements of one of the caudal vertebræ :—

	Inch.	Lines.
Length of the centrum	1	7
Vertical diameter of the convex end	1	5
Transverse diameter of ditto	1	3
Length of the base of the neural arch	1	0
Length of the base of the hæmal arch	0	9

The hæmapophysis (*h*) swells outwards at its origin, before it bends downwards, backwards, and inwards to unite with its fellow in order to complete the arch. The area or span of this arch has been considerable, as in the vertebra, fig. 5, T. IX, and as it is in the *Mosasaurus Hoffmanni*: it is probable that the spinous process continued from it had a corresponding remarkable length, but of this the fractured condition of the specimen affords no proof. The lateral surface of the centrum is smooth, with many small vascular perforations. There is a slight but well-marked rising above the base of the hæmapophysis, at *d*, which seems to indicate a last rudiment of the diapophysis. A narrow vertical ridge (*r*) extends about two lines from the border of the posterior convex surface, as if it were indicative of the limits of an epiphysis which had formed that surface. The border of the anterior concave surface has been worn or broken away. A linear impression gives also an indication of an epiphysis in the dorsal vertebra of the *Mosasaurus Hoffmanni*. The slight degree of concavity and convexity of the terminal articular surfaces of the centrum in these vertebræ is characteristic of the genus. In their special characters, the small vertebræ from Lewes correspond with the vertebræ attributed to the *Mosasaurus gracilis*, which are longer and more slender than those of the *Mosasaurus Hoffmanni*.

Genus.—Leiodon, *Owen.*

'Odontography,' p. 261, pl. lxxii, figs. 1 and 2.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 144.

The teeth from the chalk of Norfolk, surmised by Dr. Mantell, from "their symmetrical, conical form, and other characters," to belong to an unknown reptile, or to a sauroid fish;* and described and figured in my 'Odontography'† as characteristic of a new genus of Mosasauroid Reptiles, under the name of *Leiodon*,‡ presented

* Wonders of Geology, ed. 1839, vol. i, p. 339. † Vol. i, p. 261, pl. lxxii, figs. 1 and 2.

‡ Λειος, smooth, οδους, tooth.

the same acrodont type of dentition as in *Mosasaurus* and *Geosaurus*, but differed in their closer arrangement and from the former, especially, in the shape of the crown, of which the outer side was as convex as the inner side, the transverse section being an ellipse with pointed ends, which latter corresponded with two opposite trenchant edges dividing the outer from the inner side of the crown. This was covered by a smooth enamel without any indications of minor ridges or facets: the apex of the crown was sharp-pointed; the body of the crown slightly recurved; and its base expanded into a thick fang of a circular form, which was anchylosed to a short conical process of the alveolar border of the jaw.

Deducing the generic dental characters of *Mosasaurus* from the magnificent example of the jaws and pterygoid bones, which passed from Dr. Hoffmann's collection to that of the Canon Goddin, and ultimately to the Museum of the Garden of Plants at Paris, the deviation in the teeth in question from the inequilateral facetted character of the crowns of the maxillary and mandibular teeth of that specimen was so great, as to lead me to infer that these teeth from the English chalk belonged to a distinct genus of the same family of the Lacertine order; unless, indeed, they might be pterygoid teeth of a species of *Mosasaurus*, distinct from the *Mosasaurus Hoffmanni*. After a rigid comparison in reference to this question, I was led to the conclusion that they were not pterygoid, but maxillary teeth, and I therefore described them under the name of *Leiodon anceps*. The general results of that comparison, which would have been out of place in a systematic Treatise of Teeth in general, will here be requisite.

LEIODON ANCEPS, *Owen*. Tab. IX, *A*.

'Odontography,' 1840, vol. i, p. 261; vol. ii, pl. 72, figs. 1 & 2,
MOSASAURUS STENODON. *Charlesworth*. The London Geological Journal, 1846, p. 23. pls. 4 and 6.

Baron Cuvier, after a close and accurate description of the pterygoid bones of the great *Mosasaurus Hoffmanni*, concludes by stating, that "each of these bones seemed to have supported eight teeth, which grew, became attached, and were replaced, like the teeth of the jaws, but were much smaller."* They also differ from the jaw-teeth by having their two sides less unequal in regard to their convexity; the inner side is almost as convex as that side of the maxillary teeth, but the outer side of the

* "Cet os paroît avoir porté dans notre animal fossile huit dents qui croissoient, se fixoient et se remplaçoient comme celles des mâchoires, quoique beaucoup plus petites." (Ossemens Fossiles, tom. v, pt. ii, p. 324, 4to, 1824.)

pterygoid teeth is more convex than the nearly flat outer side of the maxillary teeth. They resemble, in fact, in their transverse section, the lower maxillary teeth of the *Mosasaurus Dixoni*. The alveolar border to which the pterygoid teeth are attached in the *Mosasaurus Hoffmanni*, is moderately convex towards the cavity of the mouth; the alveolar tract is relatively thicker or broader than on the jaws, and the germs of the new pterygoid teeth appear almost like a second small row on the outer side of that row which is in place, being less close to the teeth they are destined to replace than they are in the maxillary series.

The teeth in question from the English Chalk, differed in the shape of their crowns from the pterygoid teeth of the *Mosasaurus Hoffmanni*, and the alveolar border to which they were attached, more resembled that of the dentary piece of the lower jaw. In the smoothness of the enamelled crown, its compressed elliptical form and trenchant borders, which, when magnified, presented a fine serration, the teeth in question, approached to the characters of those of *Geosaurus*, as much as they deviated from those of *Mosasaurus*. Both *Mosasaurus* and *Geosaurus* afford types of the acrodont mode of dental attachment. Had only the teeth and portions of the jaws of the *Geosaurus* been known they might have been registered, on such limited evidence, as having belonged to a species of *Mosasaurus* distinct from the *Mosasaurus Hoffmanni*, and the Anatomist, Soemmerring, even supposed that the *Geosaurus* might be merely the young of that species. But the differences in the shape of the teeth are associated with differences in the structure of the cranium, of the sclerotic, and, what is still more important, in that of the vertebræ themselves, which are sub-biconcave and contracted in the middle of the centrum. With these evidences, therefore, of the importance of the differences indicated by different forms of the teeth of the acrodont *Sauria*, one may be justified in the expectation that the *Leiodon* will prove to be a genus alike distinct from both *Mosasaurus* and *Geosaurus*, and, as probably tending to fill up the hiatus that divided those genera in the series of Acrodonts, as it was known to Cuvier.

The additional evidence which has been received in elucidation of this highly interesting family of Saurians, since the publication of my 'Odontography,' has tended to confirm the conclusions stated in that work relative to the *Leiodon anceps*. The *Mosasaurus* of the Green-sand Formations in North America, has been satisfactorily shown in Professor Goldfuss's Memoir, to be a species distinct from that of the Cretaceous Deposits at Maestricht. The maxillary teeth show the same generic characters, the two sides being unequal, but with specific modifications. The pterygoid teeth are ten in number on each pterygoid bone, attached in like manner to an alveolar border, which is convex both downwards and outwards: all the crowns of these pterygoid teeth had been unfortunately broken off and lost.

Mr. Charlesworth has described and figured in the first part of the 'London Geological Journal,' a portion of jaw-bone, with five teeth, of the *Leiodon anceps*, which

he states to have come into his possession from "one of the numerous chalk-pits on the Essex side of the Thames"—the side on which the county of Norfolk lies; and it appears that the teeth described and figured in my 'Odontography' are not only specifically identical, but once formed part of the same specimen, with that which he has since figured. This may well be, for in the mass of materials which I had been collecting for six years previous to the publication of my 'Odontography' I found the drawings, which are engraved in Pl. 72, figs. 1 and 2 of that work, marked 'from the chalk of Norfolk,' without any other memorandum, and I feel obliged to Mr. Charlesworth for having publicly supplied in 1846, what my memory in 1840 failed to do, viz., the reference to the individual to whom I had been indebted in 1835 for the loan of the originals of those drawings.

With regard to the question of the nature and affinities of the *Leiodon,* the additional evidence which the figures published by Mr. Charlesworth afford, is of value. The teeth in that specimen can only be referred to the genus *Mosasaurus,* as characterised by Cuvier and Goldfuss, on the supposition that they are 'pterygoid teeth.' But, in an extent of an alveolar tract of seven inches, and including five teeth, that tract is slightly concave lengthwise, instead of being convex: and it wants the horizontal platform extended to the outside of the teeth in place, and supporting the nidus of their successors, which characterises the pterygoid bones.

In my 'Odontography,' I have briefly noticed one of the most common conditions of fossil teeth, in which the pulp-cavity has not been obliterated by calcification of the pulp itself in the lifetime of the animal. Thus, in the section on the teeth of the *Ichthyosaurus,* it is described in the following passage. "The remains of the pulp, after the formation of the due quantity of dentine, became converted, as in the pleodont lizards, by a process of coarse ossification, into a reticulate, fibrous, or spongy bone; but it continued open at the crown after the basal part of the tooth was thus consolidated, as is shown in the longitudinal section, (Pl. 73, fig. 8,) wherein *a* is the pulp-cavity, filled with crystallized spath, *b* the ossified pulp at the base of the tooth." p. 279. In fig. 2*, Tab. IX, *A*, is reproduced Mr. Charlesworth's figure of the mass of similar siliceous spath, that, in like manner, filled the uncalcified part of the pulp-cavity of the tooth of the *Leiodon anceps.* Although I should not have called this "a very unlooked for condition of the interior of the tooth," I concur with the Editor of the 'London Geological Journal' in his hypothesis of the precipitation of the siliceous matter from a fluid. But, at the same time, I am fully conscious how transparent a veil such an hypothesis is to our ignorance as to the precise conditions of the precipitation of such matter in the interior of fossil teeth, in the medullary cavities of fossil bones, and in the closed chambers of many polythalamous shells. The only wonder connected with the fact illustrated in T. IX, *A*, figs. 2 and 2*, is, that any Geologist should deem it an unlooked for or extraordinary one.

I have described and figured some small detached crowns of the teeth of the *Leiodon*,

from the Chalk-pits of Sussex, in my friend Mr. Dixon's Geology of the Tertiary and Cretaceous Deposits of that County, Tab. XXXVII, figs. 10, 11, and 12. One of the finest and most characteristic teeth of this genus was discovered in the Chalk, during the cutting of the Brighton and Lewes Railway: it is figured in T. IX, *A*, figs. 6 and 6*, and is now in the fine Collection of Henry Catt, Esq., of Brighton.

ORDER.—*CROCODILIA.*

Genus.—CROCODILUS? Tab. XV.

In the Museum of Mr. Saull, F.G.S., there is a small block of green-sand from the County of Sussex, containing several parts of a small, and apparently very young crocodile. The portion of the upper jaw, and of the right ramus of the lower jaw, T. XV, figs. 1 and 2, demonstrate the crocodilian shape and mode of implantation of the teeth, which have thick, subconical, obtuse crowns, and present proportions most resembling those of the *Goniopholis crassidens.** The alveolar border of the jaw has a similar wavy outline, and so differs from that in the Gavials and Teleosaurs, in which the alveolar border is straight. The sockets of the teeth, which are distinct at the anterior half of the jaws, run together at the posterior half, as in the Alligators and the young Crocodiles of the existing species. Several bony scutes are preserved, as, e. g., at *ss* fig. 3; none of which show the tooth-like process at one angle, which characterises many of the scutes in the *Goniopholis:* and as there is not a single centrum, or body of a vertebra to give the characters of the articular ends of that part, I am unable at present to determine the species. The femur, 65, is longer and more slender in proportion to the ischium, 63, than in the Nilotic or Indian Crocodiles: and the tibia, 66, and fibula, 67, are longer in proportion to the femur. This species evidently had the hind legs proportionably more developed than in existing *Crocodilia,* and better adapted for swimming,—a character which is observable in the Teleosaurs and some other Crocodiles of the secondary formations. At the same time it should be remembered that, in the Green-sand Formations of New Jersey, vertebræ of two species of Crocodiles or Alligators have been discovered by Professor Henry Rogers, constructed on the same procœlian type as those of existing species. See 'Quarterly Journal of the Geological Society,' January, 1849, p. 380, pl. x.

* Report on British Fossil Reptiles, Trans. Brit. Association, 1841, p. 69.

Genus.—POLYPTYCHODON, *Owen.*

'Odontography,' 1840, vol. ii, p. 19, pl. 72, figs. 3 and 4.
'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 156.

Having described in the preceding pages the fossil remains of the Class REPTILIA, from the Chalk-formations, which, as in the case of the Mosasauroids, are either referable or most nearly allied to species long known as characteristic of those Formations; or which, as in the case of the *Chelonia,* and the smaller *Lacertilia* with procœlian vertebræ, are nearly allied to the Turtles and Lizards of the present day: I next pass to the consideration of those fossils which indicate a greater deviation from modern types of the order, and which are either new, or comparatively new to Science.

In collecting the materials for my 'Report on British Fossil Reptiles' I soon found that among the evidences of that class in the Cretaceous Deposits of England, a large species of Saurian was indicated by thick conical teeth, having the general characters of the teeth of the Crocodile, but distinguished by the more regular circular transverse section of the crown, the absence of two opposite larger ridges, and the presence of numerous close-set, narrow, longitudinal ridges, continued, in some specimens, of nearly equal length to within a short distance of the apex of the crown, but in more specimens, of unequal length; a comparatively small number only of the ridges extending to near the apex: a few of the largest specimens of the teeth presented fewer and more minute ridges, and a greater degree of smoothness and polish of the enamel. Without venturing to say how far this latter character in the largest tooth might be due to age, there was a general adherence of all these teeth to a type of form and structure, which differed to such a degree from the type of any other recent or fossil teeth, as to induce me to signify such difference by applying a generic name to the extinct Reptile to which they belonged; and I accordingly described and figured them in my 'Odontography' under the name of *Polyptychodon,** in reference to their many-ridged or folded exterior.

Some of these teeth in their size, and most of them in their general aspect, resemble at first sight the teeth of the great Sauroid fish *Hypsodon,* of Agassiz, which are also found in the chalk: but those of *Polyptychodon* may be distinguished, generally, by the greater solidity of the crown, and the conformity of the structure of the dentine with that of the Crocodiles and Plesiosaurs: the ridges also on the exterior of the crown of the Hypsodon's teeth are alternately long and short, and end abruptly at different, but commonly greater distances from the apex of the tooth than in *Polypty-*

* Vol. ii, p. 19: from πολυς, many, πτύξ, a fold, οδους, a tooth.

chodon, the interspaces between the longer ridges widening as they approach the apex. The teeth of the *Polyptychodon* never offer any approach to opposite trenchant edges of the crown: but this part, presenting throughout its extent a transverse section of an almost circular form, (T. XI, fig. 7, Tab. XIV, fig. 3,) is slightly and regularly bent lengthwise, and is invested with a moderately thick layer of true enamel, of which substance the ridges are wholly composed, the surface of the outermost layer of dentine being quite smooth, (Tab. XIV, fig. 4). The teeth of the *Polyptychodon* may be distinguished at once from those of the *Mosasaurus* or *Pliosaurus* by the absence of the less convex, or almost flattened facet of the crown, which is divided by strong ridges from the remainder of the crown.

POLYPTYCHODON CONTINUUS, *Owen.* Tab. XIV, figs. 4, 5, 6.

'Odontography,' vol. ii, p. 19.

The first evidence of this species was a single tooth, which was discovered by W. H. BENSTED, Esq., of Rock Hall, near Maidstone, September 16th, 1834, in what is called the 'Trigonia-stratum' of Shanklin Sand, in the Kentish Rag Quarries near that town, this stratum being a member of the Lower Green-sand Formation. The tooth in question (T. XIV, figs. 5 and 6) has a crown upwards of three inches in length, and one inch four lines in diameter across its base. The compact dentine has been partially resolved by decomposition into a series of superimposed thin hollow cones, fig. 6, and the short and wide conical pulp-cavity is confined to the base, and beginning of the fang, which has been broken away. The cavity of the crown of the tooth in *Hypsodon* would seem to have been always much larger, as it is in many other predatory fishes in which the teeth are more rapidly shed and renewed than in the Crocodilian Reptiles. In the Collection of Henry Catt, Esq., of Brighton, is preserved the crown of a nearly equally fine specimen of the *Polyptychodon continuus,* from the Chalk of Sussex: this specimen is figured of the natural size in T. XIV, fig. 4. A portion of the ridged enamel has scaled off, exposing the smooth surface of the dentine which it protected. The teeth of this species of *Polyptychodon* differ from those supposed to have belonged to *Poikilopleuron,* in the ridges of the crown being more numerous and close set, and in the transverse section being circular instead of elliptical.

GIGANTIC FOSSIL SAURIAN FROM THE LOWER GREEN-SAND AT HYTHE. Tabs. XII and XIII.

'Proceedings of the Geological Society of London, June 16th, 1841.'

I propose to describe these remarkable and highly interesting fossils under the present section, on account of the identity of the Formation in which they were discovered, with that of the tooth of *Polyptychodon continuus* above described, and because

no other teeth have as yet been found in the Cretaceous Series to which the fossils in question could be referred. These are at present, however, the sole grounds of the probability that such teeth and bones of a large Saurian, may have belonged to the same genus.

The bones about to be described, are unquestionably the remains of a Saurian of marine habits, but most probably of the Crocodilian order, as gigantic as the *Cetiosaurus* or *Polyptychodon*, but, in the absence of any associated parts yielding the dental and vertebral characters, not certainly referable to any known genus. They were discovered, in 1840, by H. B. Mackeson, Esq., of Hythe, in the Green-sand Quarries, near that town, and include portions of the coracoid, humerus, and ulna, of the iliac, ischial, and pubic bones, a large proportion of the shaft of a femur, parts of a tibia and fibula, and several metatarsal bones, four of which exhibit their proximal articular surfaces. The remains occupied a space in the quarry, of about fifteen feet by twelve, where it would seem that a proportion of the skeleton of this gigantic Saurian, including the pelvis with one hinder extremity, and a part of the fore-limb had been exposed. In consequence of the absence of vertebræ and teeth, the present observations will be limited to indicating the characters by which these remains differ from previously known extinct genera of Saurians. In the first place, as the femur and other long bones have no medullary cavities, but a central structure composed of coarse cancelli, it is evident that the animal of which they formed part was of marine habits, and did not belong to the *Dinosauria;* but the best-preserved bone being a femur, this circumstance, independently of the size and shape of the metatarsals, at once negatives the idea that these remains belonged to the Cetacean order, whilst the form and proportions of the metatarsals equally forbid their reference to any other Mammalian genus, or to the Reptilian order *Enaliosauria.* The cells of the cancellous tissue are about a line in diameter: the compact outer crust or wall of the bone is from four to five lines in thickness. In the recent state, the cells of the cancellous structure of the marine Saurian's bones were doubtless filled with a fluid oil, as in the similarly coarsely cancellous bones of the Cetaceans, and thus the specific gravity of the animal would be nearly accommodated to that of the fluid in which it principally, if not exclusively existed.

Femur.—The portions of this bone, T. XII, fig. 1, secured by Mr. Mackeson include about the two distal thirds, excepting the articular extremity; its length is 2 feet 4 inches; its circumference in the middle, or smallest part of the shaft, is 15 inches 6 lines, and at the broken distal end, 2 feet 5 inches. These dimensions prove that the animal was equal to the most gigantic described *Iguanodon.** If the supposition of the proportion of the femur which has been preserved be right, this bone differs from that of the *Iguanodon*, not only in the want of a medullary cavity,

* The length of the largest femur yet obtained of this Saurian is 4 feet 6 inches, its smaller circumference 1 foot 10 inches.

but also in the absence of the compressed process which projects from the inner side of the middle of the shaft. The bone also expands more gradually than in the femur of the *Iguanodon*, and the posterior part of the condyles must have been wider apart in consequence of the posterior inter-condyloid longitudinal excavation being longer and wider. The middle part of the shaft of the femur is subcompressed, with a nearly quadrilateral contour of the transverse section, the line bounding the outer side being less convex and longer than that which circumscribes the inner side of the bone: the anterior surface is flatter than the posterior one. The anterior and outer surfaces meet at a more marked angle than do any of the others; the angle being formed by an obtuse ridge. The concavity of the posterior surface begins about 6 inches above the broken distal end of the present fragment, and gradually increases in both width and depth as it descends. The width of the inter-condyloid groove at the fractured distal end is 5 inches 4 lines. The same admeasurement in the largest *Iguanodon's* femur gives 2 inches. The convex ridge leading to the inner condyle is more prominent than the outer one; and on the tibial side of the inner ridge there is a second slight concavity. On the anterior surface of the distal end of the femur there is a broad shallow depression of the surface, corresponding to the deeper one behind, and there is not the narrow and deep groove which characterises the corresponding part of the femur of the *Iguanodon*. The texture of the distal end of the bone presents the same coarse cancelli as occupy the middle of the upper part of the shaft, but with a thinning of the outer laminated compact crust. The following are admeasurements of the bone not given in the above description:—

	Inches.	Lines.
Transverse diameter of the middle of shaft	5	6
Antero-posterior or lesser diameter of ditto	3	9
Greater diameter of the distal end	12	0
Smaller diameter of ditto at middle of the inter-condyloid groove	5	0

Tibia and Fibula.—The portion of a tibia, T. XIII, fig. 1, T, which has been preserved, is compressed near its head, and the side next to the fibula is slightly concave. The longest transverse diameter is 8 inches 9 lines, and the two other transverse diameters at right angles to the preceding give respectively 3 inches 3 lines, and 2 inches 6 lines. The bone soon assumes a thicker form, its circumference at about one third from its proximal end being 16 inches 6 lines. The compact laminated outer wall of the bone is 4 lines thick. The cancelli occupying the central portion of the bone are arranged in a succession of layers around a point nearest the narrower end of the transverse section. Lower down the tibia again becomes compressed, and towards the distal end the transverse section exhibits the form of a plate bent towards the fibula, and its narrowest transverse diameter is $2\frac{1}{2}$ inches.

The portion of the fibula, T. XIII, fig. 1, F, is $11\frac{1}{2}$ inches long. In the middle it is flat on one side, slightly concave on another, and convex on the two remaining sides.

An outline of a section of this part is given at Fig 1. It presents the same cancellous structure as the tibia, but the concentric arrangement of the layers of cells is more exact. Towards the opposite end of the bone the concave side becomes first flat, and is then produced into a convex wall, terminating one end of a transverse section of a compressed and bent thick plate of bone. The long diameter of this section is 6 inches 6 lines at the end of the fragment; 4 inches from that end it measures 5 inches 6 lines: the shorter diameter of the compressed bone at the same part is 1 inch 10 lines; an outline of the transverse section of this part is given in Fig. 2. Of several long and strong bones, which from their form and relative size represent metatarsals, there are considerable portions of four, detached, with their proximal articular surfaces preserved; a fifth, wanting the articular extremities; and two others longitudinally split and imbedded in a mass of the Green-sand matrix; these latter exhibit the characteristic inequality of length of the Crocodilian metatarsals, and are probably the innermost and second metatarsals of our present gigantic Saurian.

Fig. 1

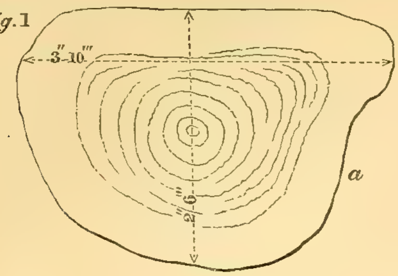


Fig. 2

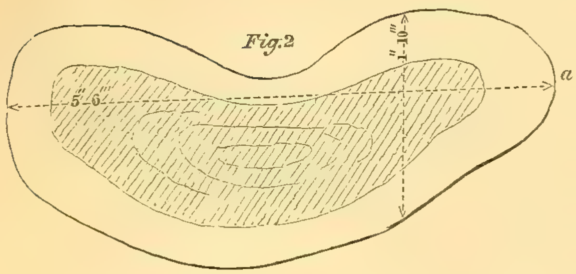
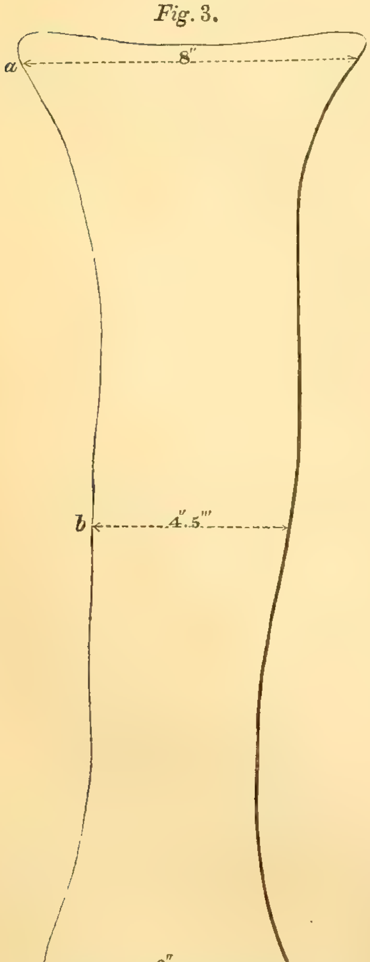


Fig. 3.



Outline of an imbedded metatarsal of the *Polyptychodon*. Scale 2½ inches to a foot.

The innermost and smallest measures one foot in length; the adjoining metatarsal two feet. Their position in the rock shows that the part of the skeleton had been separated through decomposition before they were permanently imbedded, the proximal articular extremities being 3 inches apart, but on the same transverse line.

The outline of the larger of these imbedded metatarsals is subjoined at fig. 3; its transverse diameter at *a*, is 8 inches, at *b*, 4 inches 5 lines, and at *c*, 6 inches.

The smaller metatarsal is more contracted at the shaft which presents a triedral contour: the diameter of its greater end is 5 inches; that of the narrow part of the shaft is 1 inch 11 lines; its compact outer crust is between one and two lines thick; all the rest of the substance presents a cellular texture, the cells having a diameter of one half to two thirds of a line.

Fig. 4.

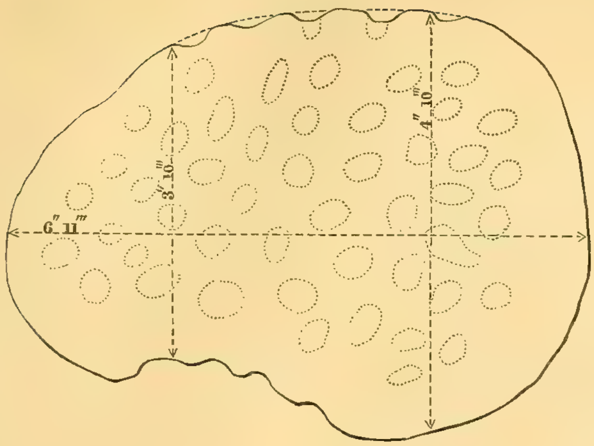


Fig. 6.

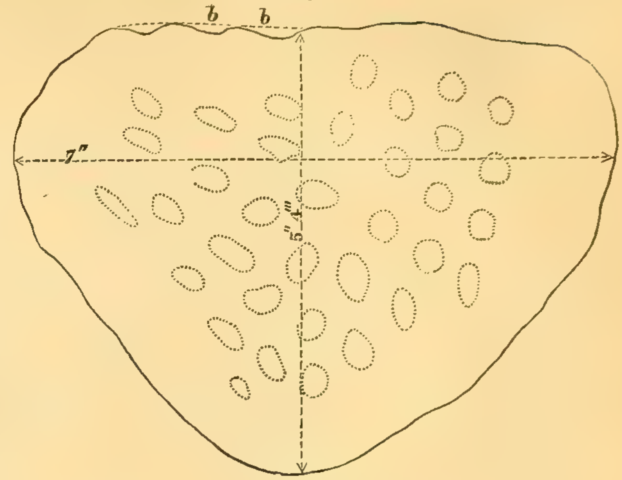
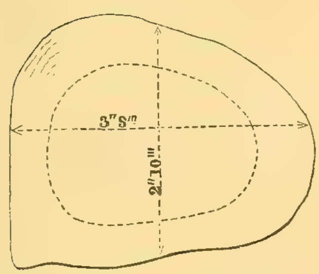
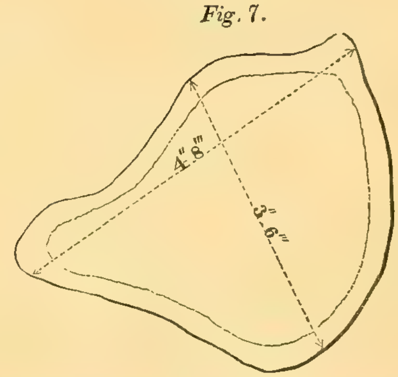


Fig. 5.



Proximal end and section of shaft of a metatarsal of *Polyptychodon!*

Fig. 7.



Proximal end and section of shaft of a metatarsal of *Polyptychodon!*

Of the detached metatarsals I subjoin outline sketches of the articular end, and the transverse section of the shaft for facilitating the comprehension of their form and their comparison with other remains. The chief of these is the proximal portion of a metatarsal bone 15 inches, 6 lines in length. Figure 4 is the contour of the articular end, which is slightly convex at the smaller side, nearly flat at the wider one, and with a very irregular superficies, being pitted all over with depressions admitting the end of the little finger, these depressions at some parts of the circumference of the articular end being continued into as broad grooves, which soon subside to the level of the surface of the shaft. Figure 5 is the outline of the fractured end, nine inches from the articular end of the same bone: the angle indicates a ridge which runs obliquely down the bone towards the middle of the surface, and subsides near the broken end, fifteen inches down the shaft. The dotted line indicates the thickness of the laminated wall, which gradually becomes less compact, and encloses a coarse cancellous structure. The outer surface of the bone is smooth.

Figure 6 gives the contour of the articular end of a proximal portion of a metatarsal bone 11 inches long. The articular surface is pitted with cavities, as in fig. 4, the size of the same, as if for a coarse ligamentous articulation: the cavities are continued into grooves at *b b*. Figure 7 gives the contour of the broken surface, six inches

below the proximal end: the whole thickness of the bone, within the compact outer wall, being occupied by a coarse cancellous structure.

Fig. 8.

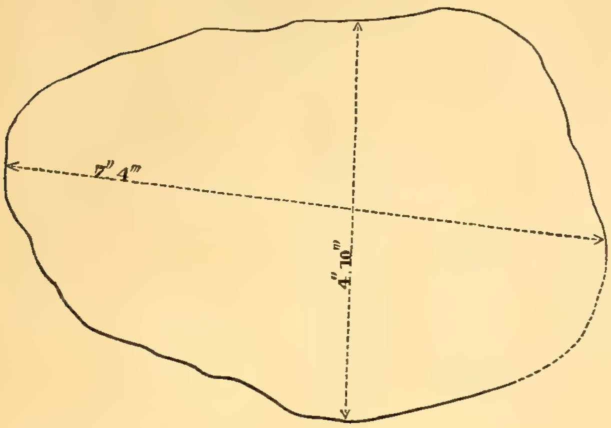


Fig. 10.

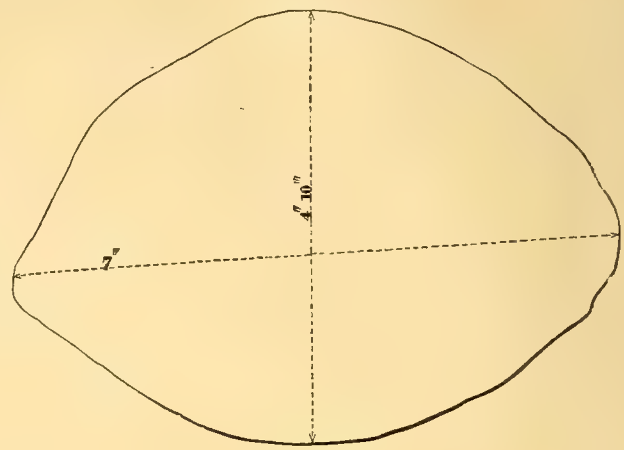
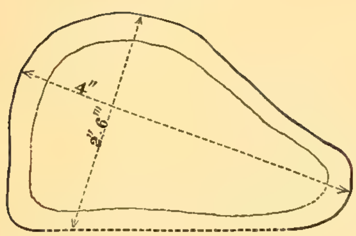
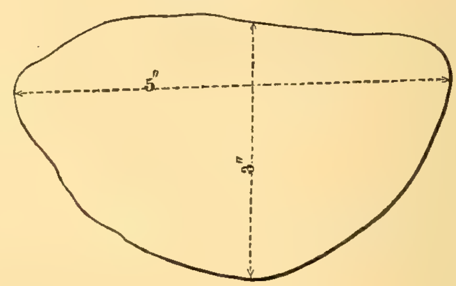


Fig. 9.



Proximal end and section of shaft of a metatarsal bone of *Polyptychodon.*

Fig. 11.



Of a fragment, 12 inches long, of the proximal portion of a metatarsal bone, figure 8 gives the contour of the articular end; and fig. 9 of the fractured end of the shaft; the dotted outline indicates where the outer crust of the wall prevented an exact figure of the contour being made; but the shaft of the bone seemed to have been flat on that side.

A fourth fragment of a long bone measured 10 inches in length. Figure 10 gives the contour of the proximal articular end of this bone (the outer wall having scaled off). Figure 11 is the contour of the fractured end of the shaft, 5 inches beyond the articular end. It is occupied by a coarse cancellous structure throughout.

There remain to be noticed some less perfect fragments of huge flat bones imbedded, or indicated by their impressions, in masses of the Green-sand Rock. In three of these I recognise the ilia, ischia, and pubes: they are broader than in the Crocodiles, but would be conformable to the Crocodilian type, if the cartilaginous parts of some of those bones in the recent species were ossified: by this greater extent of ossification of the large fossils in question, the pubis and ischium approach somewhat to the Plesiosaurian type. The ilia are imbedded in the same block of stone: they are flat,

nearly straight, and become gradually wider and thicker towards the end attached to the sacrum: of these bones a portion 25 inches long is preserved of the one, (T. XII, fig. 6,) and 20 inches of the other: the broadest end of the longer portion measures across 10 inches. In a second block, the mesial extremities of the pubis and ischium are preserved. The exposed surface of the pubis is principally convex, but becomes concave towards the opposite or median margin: it measures across at its broadest part 13 inches; the length of the fragment preserved is 17 inches. The diameter of the corresponding expanded extremity of the ischium is 9 inches: its expanded extremity is obliquely truncated; that of the pubis is rounded. In another block the expanded extremity of the opposite pubis is preserved; it measures 14 inches across, and is 22 inches in length.

In a third large mass of rock, the fragment of an enormous, apparently subquadrilateral flat bone, is exhibited, which most probably belongs to the pectoral arch, and, in that case, must be the coracoid bone, T. XII, fig. 5, P. The length of this fragment is two feet, its greatest breadth 17 inches: its thickness varies from 3 to 5 inches. On one side there is a slight submedian ridge, from which the surface slopes away with a gentle concavity.

The breadth of this bone indicates the great development of the muscles destined for the movement of the fore-leg, whence it may be inferred that the anterior extremities were more powerfully and habitually used in progressive motion than in the Crocodiles. In the existing species of this family, the anterior extremities are used chiefly for the support and movements of the body on land; they are applied to the sides of the chest when the animal swims, which is chiefly effected by the actions of the strong and long vertically compressed tail. The lateral movements of the fore-legs being much restricted, the coracoid bone and the muscles arising from it are comparatively slender. In the Enaliosauria, where the fore-legs are converted into paddles for swimming, the coracoids are vastly expanded, both for the increased strength of the shoulder-joint and the increased surface for the attachment of the muscles, which effect the lateral movements and the stroke of the paddle-shaped limb upon the water. We may infer, therefore, that the anterior extremities of the present gigantic Crocodilian were, by some webbed modification of the hand, better adapted, and more energetically used for swimming than in the existing Crocodilians.

The shaft of a long bone somewhat similar to, but shorter and more slender than the femur, and crushed, is preserved with that of a smaller bone, tapering more gradually to one end, in the same block of stone: these are figured in T. XIII, fig. 2; the larger bone is probably the humerus, H, the smaller one the ulna, U.

Other less intelligible fragments of the long bones of the same great Saurian are represented in T. XII, figs. 2, 3, and 4; and in T. XIII, figs. 2 and 4. Fig. 3 probably shows two of the metacarpals in the same block of stone.

The principal parts above described are preserved in the British Museum, to

which Institution they were liberally presented by their discoverer H. B. Mackeson, Esq. They were mutilated in the attempt to disencumber them of the massive blocks of the matrix in which they were imbedded, and are less characteristic than when I took the foregoing description and sketches of them on the spot where they were found.

It has been shown that the texture of the femur, tibia, fibula, and the other long bones, is conclusive against the identity of the Saurian of the Hythe Lower Green-sand with the great ambulatory Dinosaurian reptiles, viz., Iguanodon and Megalosaurus, the former discovered in the Lower Green-sand at Maidstone, and both species also in the Wealden and Oolite Formations; there then remains to be considered its relationship with the Enaliosaurians, the Crocodilians, the Mosasaur, and Poikilopleuron.

The length, thickness, and indication of condyles in the femur, and the length, thickness, and angular form of the metatarsals, place the Plesiosaurs, and, *à fortiori*, the Ichthyosaurs, out of the pale of comparison.

The superior expanse of the pubis, and the broad coracoid (?) with the form of the femur, and the gigantic proportions of all the bones, forbid a reference of the Saurian in question to any subgenera, recent or extinct, of the Crocodilian Reptiles, of which the bones of the extremities were previously known.

If it were true that the *Mosasaurus* had locomotive extremities in the form of flattened paddles, like the *Plesiosaurus*, the identity of our present Reptile with the Maëstricht species would be at once disproved, by the unequivocal remains of the metatarsal bones, which indicate a form of foot, corresponding, as far as the skeleton is concerned, with that of the Crocodile: and if, as is most probable, the metatarsals of the Lacertian type from the Green-sand of New Jersey appertain to a *Mosasaurus*, the metatarsals from the Green-sand at Hythe differ from them in size, shape, and the absence of any medullary cavity.

With regard to the Crocodilians, the extinct genus which most closely agrees with the characters of the bones of the Hythe Saurian is that which I have named *Cetiosaurus*, the vertebræ of which have been found in the Wealden and Oolite formations, and the long bones of which are devoid of a medullary cavity. Unfortunately no vertebra referable to *Cetiosaurus* has yet been discovered in the Cretaceous deposits. It is possible that the teeth on which the genus *Polyptychodon* has been founded may belong to *Cetiosaurus*; but hitherto such teeth have not been discovered in the strata where the remains of *Cetiosaurus* are common.

The gigantic Saurian discovered by M. Deslongchamps, in the Oolite at Caen, and which he has named *Poikilopleuron Bucklandii*, yields for comparison with the Hythe Saurian the femur, fragments of the tibia, fibula, and metatarsal bones.

In the form of the condyles of the femur, and their posterior intervening channel, the Hythe Saurian resembles the Poikilopleuron more than it does the Iguanodon; but the large medullary cavity in the femur of the Poikilopleuron distinguishes it as

much as it does that of the Iguanodon from the Hythe Saurian. The medullary canal is described as being very great in the tibia of the Poikilopleuron.*

The absence of vertebræ and teeth in the Hythe specimen prevents the establishment of a comparison of these instructive parts of the skeleton of the two extinct Saurians, and the question of the dental characters of the Poikilopleuron remains in the same doubtful state as it is left by M. Deslongchamps, who describes and figures a detached large Crocodilian tooth from the Oolite near the village of Allemagne, as corresponding in size with the remains of the Poikilopleuron.†

M. Deslongchamps conceives it may be useful to make known these teeth at the same time with his Poikilopleuron, leaving to subsequent discoveries the determination of the truth or otherwise of the approximation. For the same motive I have prefixed to my account of the Hythe Saurian a description of the teeth of a gigantic, and hitherto unknown Saurian from the Green-sand at Maidstone, and shall append to it an account of similar teeth from the Chalk Formation in Sussex, Kent, and Cambridgeshire.

Since the bones of the extremities of Mr. Mackeson's large reptile from the Green-sand afford sufficient evidence of their distinctness from the tallying parts of any previously described Saurian genus, and since we have evidence as satisfactory of an equally gigantic Saurian genus from the teeth which occur in the same Formation, it may be allowable, for the purposes of the present record, to regard both the bones and the teeth as parts of the same animal. Until, therefore, further evidence is obtained, showing the Hythe skeleton to have been furnished with differently-formed teeth, or the teeth from the Maidstone Green-sand to have been associated with a differently constructed skeleton, I shall apply to the Hythe fossil the name of *Polyptychodon*, under which the genus of gigantic Saurian, hitherto known only in the Green-sand and Chalk strata, was first indicated.

POLYPTYCHODON INTERRUPTUS, *Owen*. Tab. X, figs. 7, 8, 9; Tab. XI; Tab. XIV, figs. 1 and 2.

'Odontography,' vol. ii, p. 19, pl. 72, fig. 4; and in Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex,' p. 378.

The majority of the specimens of the teeth of this species have been found in the middle and lower Chalk or Chalk-marl: one large tooth of this species has been

* "Le canal medullaire était fort grand; l'epaisseur du tissu compact, en *d*, est d'environ 0$^{m.}$ 015." (Deslongchamps, 'Sur le Poikilopleuron,' 4to, p. 55.)

"Dans ce tiers inférieure, le femur est un peu plus étendu transversalement que d'avant en arrière." (Deslongchamps, loc. cit.)

† "On a trouvé, à diverses epoques, dans les carrières du Village d'Allemagne de grandes dents, toujours isolées, offrant tous les caracterès de celles des Crocodiles. J'en figure une, pl. vi, (de grandeur

discovered by the Rev. Peter Brodie, M.A. F.G.S., in the upper Green-sand at Barnwell, near Cambridge, and a few other specimens have been obtained by James Carter, Esq. from the Green-sand of another locality, near Cambridge.

The fine examples of teeth figured in T. XI (with the exception of fig. 8) were discovered in 1847 by Mr. Potter, of Lewes, in the lower bed of Chalk-marl, just above the Green-sand, in the vicinity of that town. They formed part of as many as from twenty to thirty teeth of nearly the same size which were scattered at no great distance from each other. No part of the jaw-bones could be detected; and as the teeth are fully formed, and some of them retain their long fangs, it may be inferred that they were originally implanted freely, like the teeth of the Crocodile, in loose sockets, and have dropped out as easily, after the decomposition of the gums and other soft parts. The crown is about two sevenths the length of the entire tooth, and its enamelled striated coat terminates by an abrupt and well-defined border; the fang continues to expand to about its middle part, whence it gradually contracts to an obtuse end, which is perforated by the entry to the pulp-cavity. The general shape of the crown agrees with that of the *Polyptychodon continuus;* the difference is shown by the greater proportion of the ridges which stop short of the apex of the crown, especially on the convex side of the tooth. In using the term convex or concave as applied to the crown, allusion is made to the slight bend of crown in the direction of its axis. Around the entire basal part of the crown the ridges are close together: their interspaces are only the clefts that separate them. On the concave side of the tooth a large proportion of the ridges extend nearly to the apex, as is shown in T. XI, fig. 1; but on the convex side a greater number extend only one third or two thirds towards the apex, these shorter ridges alternating with the longer ones, between which, therefore, at the apical part of the tooth, there are intervals of flat tracts of enamel. The apex of the tooth is rather obtuse. On one side of the crown there is a long ridge, towards which contiguous shorter ones have a convergent inclination. The long fang of the tooth is covered by a layer of smooth cement. The dentine is compact, and corresponds in microscopic structure with that of the crocodile's teeth. In the fractured specimens of the teeth from Lewes, the dentine had become resolved into superimposed conical layers, as in the larger tooth from the Green-sand of Maidstone: this effect of long interment is represented in figs. 1, 3, 5, and 7, of T. XI. There is no trace of the absorbent action excited by pressure of a successional tooth in any of these specimens of teeth.

Although the detached state of the above-described teeth with well-developed fangs would have suggested and sustained the inference that they had been implanted like

naturelle, fig. 8, reduite au quart, fig. 9.) Elles ont intériurement une cavité conique; leur surface couverte d'email jusqu'à une certain distance de leur base, est ornée des stries en relief, longitudinales, de longeur inégale, dont deux seulement, situées aux extremités du même diamètre, arrivent jusqu'à la pointe." (p. 80.)

the teeth of the Crocodile, direct evidence to that effect had not been obtained at the time of the publication of my 'Report on British Fossil Reptiles;' and it has been objected that the mode of fixation of the teeth of the Polyptychodon might have been the same as in the Mosasaurus, and that those teeth might belong to a second extinct genus of gigantic Sea-lizards. The specimen, however, which is represented of the natural size in T. X, fig. 3, inclines the balance in favour of the Crocodilian affinities of the Polyptychodon, by proving that its teeth were implanted in distinct sockets, and not anchylosed to the summits of processes of the jaw, as in *Mosasaurus* and *Leiodon*. In the figure cited, taken from an unique specimen of part of the lower jaw of the *Polyptychodon interruptus* discovered in the lower chalk-deposits of Kent, and now in the collection of Mrs. Smith, of Tonbridge Wells, the letter *b* shows the smooth cement-covered cylindrical base, and *c* the enamelled conical crown; *s* is an adjoining vacant alveolus, from which a tooth similar to that in place has slipped out, like the teeth from the Lewes Chalk-marl. The crown of the tooth in place is rather longer in proportion than in most of the detached teeth from Lewes; and it may, therefore, indicate a certain inequality in the length of the crowns of the teeth in the same jaw, as in the Crocodiles, and it may have answered to the tooth which is sometimes called, on account of its greater length, the "canine tooth" in the Crocodile. The socket anterior to the one with the completed tooth contains the germ of a young tooth, *e*, and shows that the teeth succeeded each other from the same sockets as in the modern Crocodiles.

The crown of a much larger tooth of the *Polyptychodon interruptus*, which is figured in Tab. IX, figs. 16 and 17, was found near Valmer, during the cutting of the Lewes railway, and is now in the museum of Henry Catt, Esq., F.G.S., of Brighton. It shows well that alternate and interrupted character of the longitudinal ridges of the enamelled surface which distinguishes the present species, but the ridges have been more worn down, especially towards the apex, in Mr. Catt's specimen, than in the one originally figured in my 'Odontography.'* The body of the crown consists of a hard compact dentine, partly resolved in the specimen by incipient decomposition into superimposed hollow cones, like the similarly-sized tooth of the *Polyptychodon continuus* from Mr. Bensted's Green-sand "Iguanodon" quarry at Maidstone.† The cylindrical case of the tooth is excavated by a wide conical pulp-cavity with an obtuse summit, into which a small central process projects from the base of the crown (fig. 17). The enamel is very thin at the base of the crown.

Figure 8 in Tab. XI, is the crown and part of the base of a still larger tooth of apparently the same species of *Polyptychodon* obtained by Mr. Catt in October 1850, from the grand and picturesque chalk-pit, or rather chalk-cliff, at Houghton, near Arundel.

* Odontography, pl. lxxii, figs. 4, 4'.

† Ib. fig. 3, and 'Report on British Fossil Reptiles,' p. 156.

One or two of the long ridges of this tooth are more than usually prominent, and most of the shorter ones are fainter than usual; but I cannot regard those differences in any other light than as individual varieties. The pulp-cavity at the base of the tooth, filled up in the specimen by the white chalk, appears to have been unusually large, as if the specimen had been in an incompletely developed state. If this were the case, it must have come from a very large specimen of the present species of extinct reptile.

To such a specimen must have belonged the anterior end of the left ramus of the lower jaw, (T. XVI,) discovered in the Burham Chalk-pit, in Kent, and now in the choice and instructive Collection of J. Toulmin Smith, Esq. The fragment is upwards of a foot in length, but contains only three alveoli, and corresponded, probably, to the premaxillary part of the upper jaw of the same animal. The first socket, *s* 1, is nearly three inches from the fractured end of the jaw, and two inches from the larger socket, *s* 2, behind it; the third socket, *s* 3, is closer to the second. These are filled up by the chalk, the teeth having fallen out. The outer surface of the jaw is convex and prominent; a solid mass of the bone extends horizontally inwards from the anterior socket, to form the symphysis, which seems to have been ossified, with the opposite ramus. The substance of the bone has the same coarse cancellous tissue as that of the portion of the smaller jaw of *Polyptychodon*, (T. X, fig. 7); and, as it shows a similar inequality in the intervals of the alveoli, it may be concluded to belong to the same genus, if not species, of extinct Crocodilian reptile. The present fragment indicates an individual as large as the great *Mosasaurus*, the skull of which was discovered in the Maestricht Chalk.

Fine specimens of crowns of the teeth of both species of *Polyptychodon*, T. X, figs. 8 and 9, have been obtained by James Carter, Esq., M.R.C.S., of Cambridge, from the Upper Green-sand near that town, and also at Horn-sea, in the same county. These specimens present a darker colour than those of the chalk, by reason of the modification of their matrix. The ridges are remarkably well defined on the enamel; the dentine presents the same well-marked division into layers, cone within cone, as in the Chalk specimens, and that from the Shanklin sand near Maidstone. The crown of one of the specimens of the *Polyptychodon interruptus* from the Cambridge Green-sand, equals in size that of the *Polyptychodon continuus*, discovered by Mr. Bensted in his quarry near Maidstone.

ORDER. *ENALIOSAURIA.*

Genus.—PLESIOSAURUS, *Conybeare.*

Besides the teeth which, according to their form and structure, were referable to the different genera and species of *Reptilia* above described,—viz. to *Raphiosaurus*,

(T. X, fig. 5;) to *Coniosaurus,* (T. IX, fig. 14*a*;) to *Mosasaurus,* (ib., fig. 1;) to *Leiodon,* (T. IX*A*, fig. 1;) and to *Polyptychodon,* (T. XI and T. XIV,)—we now, for the first time, in our progressive researches, descending through the strata which indicate the changes which the part of the earth's surface forming England has undergone, meet with teeth of different and peculiar type, remarkable, viz., for their length and slenderness, and with a circular transverse section, not subcompressed or with opposite trenchant margins, as in the Gavials of the Tertiary deposits. The tooth represented of the natural size in T. IX, fig. 8, is a good example of one of those of the form in question. Its enamelled crown, if entire, would exceed an inch and a half in length, yet it is but half an inch in diameter at its base; the crown is slightly curved and tapers gradually to a point; the enamel presents some slender but well-defined longitudinal ridges of different lengths, and none of them extending to the apex. The fang or root is cylindrical, smooth, and covered by a thin cement. The tooth above described was obtained from the Scaddlescombe Chalk-pit, near Lewes, Sussex.

A similar specimen, rather more fractured, T. IX, fig. 10, was found in a Chalk-pit at Southeram, Sussex.

A smaller tooth, (T. IX, fig. 9,) of the same type, but with more numerous longitudinal ridges, seems to indicate a different species. This specimen was also found at Southeram.

If satisfactory and abundant evidence of the nature of the extinct reptile to which the above-described teeth belong had not been obtained from Secondary Formations of a more ancient date than the cretaceous ones, the Comparative Anatomist would have inferred, and correctly, the generic distinction of the Reptile to which they belonged; but he could-have had no suspicion of the truly extraordinary nature of the animal, the entire race of which, after flourishing under a variety of specific forms from the epochs of the Muschelkalk and Lias, finally perished at the time of the deposition of the Chalk.

The anatomical description of the *Plesiosaurus,* discovered and restored by Conybeare and De la Beche, will be reserved for the Monograph descriptive of the fossil Reptiles of the formations in which its remains are most abundant; and I shall here limit myself to quoting the brief but graphic definition of it which Dr. Buckland has given in his interesting and instructive 'Bridgewater Treatise:'—"To the head of a Lizard it united the teeth of a Crocodile; a neck of enormous length, resembling the body of a Serpent; a trunk and tail having the proportions of an ordinary quadruped; the ribs of a Chameleon; and the paddles of a Whale. Such are the strange combinations of form and structure in the Plesiosaurus," (p. 102.) I may add, that of all existing Reptiles the Chelonians make the nearest approach to the present remarkable extinct genus in the length and flexibility of the neck, in the size of the true body of the atlas, which resumes its normal relations with the neural arch of that vertebra in *Chelys* and *Chelodina,* as in *Plesiosaurus;*

in the natatory form of the extremities as exemplified in the paddles of the Turtle, which besides being four in number, come much nearer those of the *Plesiosaurus* in structure than the paddles of the Whale do, and in the great expanse of the ischium and pubis: whilst the Plesiosaurs exhibit, next to the Turtles, the greatest development of the abdominal ribs (hæmapophyses and their spines), which form a kind of interwoven flexible "plastron" beneath the abdomen.

Plesiosaurus Bernardi, *Owen*. Tab. XVIII.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' p. 396.

In my 'Report on British Fossil Reptiles,' one species of *Plesiosaurus*, viz. *Plesiosaurus pachyomus*, was defined from remains discovered in the green-sand division of the Cretaceous series;* and the existence of the genus *Plesiosaurus*, at the period of the deposition of the latest member of that series, was inferred from the discovery of the femur of a large species in the chalk which forms the well-known "Shakespeare's Cliff" near Dover.†

This indication has been since confirmed by the discovery not only of the teeth above described, but of vertebræ of the *Plesiosaurus* in the same formation; and the cervical vertebra figured in T. XVIII, which was obtained from the Upper Chalk at Houghton, near Arundel, Sussex, indicates a species allied to the *Plesiosaurus pachyomus* from the green-sand of Cambridge.

The following are the dimensions of the vertebra from Houghton, and of the most perfect of those of the above-cited species from the green-sand.

	Pl. pachyomus.		*Pl. Bernardi.*	
	Inches.	Lines.	Inches.	Lines.
Antero-posterior diameter of centrum	2	0	1	9
Transverse diameter	2	9	3	0
Vertical diameter	2	6	2	0

The breadth of the centrum is proportionally greater in the vertebra from the chalk, which further differs from that from the green-sand in the lower position, and the anchylosis of the pleurapophyses, *pl* (hatchet-bones or cervical ribs); which, if they presented the characteristic expansion of their extremities, must have supported the hatched-shaped head on an unusually long body or pedicle. The articular surfaces of the centrum are more concave than in most *Plesiosauri*, and deepen to a central pit, in which they resemble those of the *Plesiosaurus pachyomus;* but the circumference of the articular surface is more extensively rounded or bevelled off, so that its convexity is seen, as at *c a*, *c p*, upon a side view of the vertebra, fig. 3, Tab. XVIII.

* Report on British Fossil Reptiles, Trans. Brit. Association (1839), p. 74.

† Ibid., p. 193. This specimen was kindly transmitted to me by J. Wickham Flower, Esq.

Both neurapophyses, fig. 3 (*n*), and pleurapophyses (*pl*) are anchylosed to the centrum. The neurapophyses coalesce together, and send almost vertically upwards a spinous process, which exceeds in length the whole vertical diameter of the vertebra below it, and is more than twice its own antero-posterior diameter; it is compressed and gradually decreases in thickness as it rises; it presents a rough shallow tract along its fore part (fig. 1), and a wider, deeper, and smoother excavation behind (fig. 2). Two small zygapophyses are developed from both the fore-part (*z*) and back part (*z'*) of the neural arch. The pleurapophyses (*pl*) are long, sub-depressed, slightly expanded as they extend downward, outwards, and backwards; but the fractured ends do not show how far they have extended forwards and backwards into a hatchet-shaped extremity. They have coalesced with the lower part of the sides of the centrum, an extent more than their own vertical diameter intervening between them and the base of the anchylosed neurapophyses. The articulated cervical ribs in the *Pl. pachyomus* have not quite so low a position on the centrum, and are thicker vertically.

The under part of the centrum presents two deep pits from which the vascular canals ascend, divided by a moderately thick, convex, longitudinal bar (fig. 4). The non-articular surface of the centrum is smooth, and the sides of the centrum are slightly concave.

A very interesting and well-marked species of the singular genus *Plesiosaurus,* in addition to those from the older secondary strata, is thus indicated by the present unusually perfect fossil vertebra. As it was discovered on one of the estates of his Grace the Duke of Norfolk, I avail myself of the opportunity of fulfilling a wish of my lamented friend Mr. Dixon, and of gratifying my own, by dedicating this new species to the memory of Lord Bernard Howard, a young nobleman of great promise and most amiable disposition, and who had given much attention to the science of geology: he died suddenly in Egypt at the early age of twenty-one years, whilst pursuing his travels in order to acquire a knowledge of the antiquities, the arts, and policy of distant countries.

Plesiosaurus constrictus, *Owen.* Tab. IX, figs. 6 and 7.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' p. 398.

The species of *Plesiosaurus* from the Chalk-pit at Steyning, Sussex, indicated by the centrum of a middle cervical vertebra, which is figured in T. IX, figs. 6 and 7, differs from that of the *Plesiosaurus Bernardi,* (T. XVIII,) in its great length, as compared with the height and breadth of the articular surfaces of the centrum, and in the small size of the costal articulation (*pl*), the pleurapophyses having been unanchylosed to the centrum; it also differs from all the species of Plesiosaur hitherto defined in the degree

of lateral constriction of the centrum between those surfaces, if this be natural. The free or non-articular surface of the centrum is rugose, showing the coarsely fibrous texture of the bone. The under surface (fig. 6) is slightly concave, both transversely and longitudinally, is subquadrate and oblong, with two approximated vascular orifices at its centre, separated by a slight rising, which is not developed into a ridge. The small costal surfaces (*pl*) are elliptic, situated at the middle of the ridge dividing the under from the lateral surfaces of the centrum, twice their own vertical diameter below the neurapophysial surfaces, and equidistant from the two ends of the centrum. The articular surfaces here are convex at their circumference, slightly concave in the rest of their extent, with a feeble longitudinal rising at the centre, interrupted by a transverse linear groove. The neurapophyses terminated below in a very open angle. The vertebra appears to have been subject to pressure, and is slightly distorted; but it is difficult to conceive how this could have operated so partially as to have produced the compressed character of the middle of the centrum and have left the two articular ends of their natural form.

The following are its principal dimensions.

	Inches.	Lines.
Antero-posterior diameter of centrum	2	4
Transverse diameter of articular surface of ditto	2	2
Vertical diameter of ditto	1	$7\frac{1}{2}$
Distance between the neurapophysial and costal pits . . .	1	0
Transverse diameter of middle of centrum above the costal pits	1	7

It is most probable that the teeth of the *Plesiosaurus*, T. IX, figs. 8 and 9, belong, by reason of their size, to the *Plesiosaurus Bernardi.*

A much-fractured tooth, (Tab. IX, fig. 10,) as thick as those of figs. 9 and 18, but diminishing more rapidly to the apex, shows similar unequal but more numerous ridges all round the enamelled surface; its crown is composed of the same kind of hard dentine as in the Crocodiles and Plesiosaurs, with a moderately thick covering of enamel. The tooth may be a variety of the Plesiosaurian type, or it may have belonged to a Steneosauroid Crocodilian. It was obtained from the same chalk-pit, at Houghton, near Arundel, as the vertebra of the *Plesiosaurus Bernardi.*

The teeth, figs. 7 and 8, T. XX, present more slender proportions, and so far, are more strictly Plesiosauroid. The fang is round, smooth, and deeply excavated by the pulp-cavity, which is indicated by the dotted line at *p;* the enamelled crown supports numerous fine longitudinal ridges: it is rather more compressed at its fractured end than in the typical Plesiosaurian teeth. These specimens were found in the lowest bed of the Lower Green-sand beneath Shanklin Chine, Isle of Wight; I am indebted for the drawings of them to John Edward Lee, Esq., of the Priory, Caerleon, Monmouthshire.

VERTEBRA OF A PLESIOSAURUS.

The subject of T. XIX is a mutilated vertebra, there figured of the natural size, which was obtained from the Chalk-pit at Burham, in Kent, and is now in the Collection of Mrs. Smith, of Tunbridge Wells.

The centrum, slightly concave at both ends, with a large vertically oval depression, fig. 3, *pl*, for a rib on each side, and with a pair of vascular foramina on its under surface, fig. 2, *c*, *c*, shows the characters of the genus *Plesiosaurus*, with which the structure of the neural arch is conformable.

The following are the chief dimensions of this vertebra.

	Inches.	Lines.
Antero-posterior diameter of the centrum	2	2
Transverse diameter of its articular end	3	0
Vertical diameter of ditto	3	0

This vertebra differs from that of the *Plesiosaurus Bernardi*, not only in the proportions indicated by the dimensions above given, but likewise by the non-anchylosis of the rib, and by the shape and position of the surface for its attachment to the centrum: and if the value of these differences were to be questioned on the ground that the present vertebra might be one nearer the back than the vertebra figured in T. XVIII, at which part of the spine the cervical ribs increase in size, have their junction raised nearer to the neural arch, and retain longer their individuality in the species in which they become anchylosed in the more advanced vertebræ, there would still remain the following differences:—the vascular foramina on the under surface are not situated in such deep and well-defined pits; the concave terminal articular surfaces have not the central depression: the sides of the centrum are not bevelled off at the border of these articular surfaces, but are divided from them at a right angle by a well-defined margin. My present experience of the constancy of such secondary characters in the cervical vertebræ of the same species of *Plesiosaurus*, leads me to conclude that the vertebra figured in T. XIX is of a distinct species of *Plesiosaurus* from that figured in T. XVIII, a conclusion to which we are also led by the consideration that the vertebral bodies usually gain in breadth as they approach the back, whilst the vertebra, (T. XVIII,) with a lower placed rib, is relatively broader than the present one. From the *Plesiosaurus pachyomus*, from the Green-sand of Reach, near Cambridge,* the present specimen differs in the form of its costal surface, which is vertically instead of being transversely elliptical: it is still more obviously distinct

* Report on British Fossil Reptiles, 1839, p. 74.

from the *Plesiosaurus constrictus,* from the Chalk of Steyning, in Sussex. Although the sutures connecting the neural arch with the centrum are traceable, there has been a certain degree of anchylosis, which has helped to maintain the arch in its natural connection, notwithstanding the degree of pressure and distortion to which the whole vertebra has been subject. Each neurapophysis, which measures one inch five lines in antero-posterior diameter at its narrowest part, is smoothly rounded off at both its free borders, of which the anterior one is the thickest; the posterior zygapophysis is developed at rather more than an inch above the base of the neurapophysis; its flat oval articular surface looks downwards, and a little outwards: the neural canal is relatively wider than in the *Plesiosaurus Bernardi,* and its area is oval, with the great end downwards. The spinous process, of which nearly four inches is preserved, has an antero-posterior diameter at its base, of nearly two inches, and is strengthened behind by two buttress-like ridges, which rise converging from the summit of each posterior zygapophysis: bounding an angular depression at the back part of the spine, as in the *Plesiosaurus Bernardi,* and many other species. The total height of this vertebra, as far as the spine is preserved, is seven inches and a half, and the total length of the Plesiosaurus, to which it belonged, was probably not less than sixteen feet. There are preserved in the same block of Chalk with the vertebra above described, the summit of the neural arch, with the base of the spine of another vertebra, and a portion of one of the long ribs of the thorax, fig. 1, *pl.*

PLESIOSAURUS PACHYOMUS, *Owen.* T. XX, XXI.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1839.

This species of *Plesiosaurus* was founded on certain remains discovered in the Upper Green-sand at Reach, about six miles from Cambridge, and placed by the Rev. Professor Sedgwick in the Wordwardian Museum of that University.

The specific name "*pachyomus*"* relates to the unusual thickness of the humerus, the distal flattened end of which is one inch and a half thick, the breadth of the same part being only four inches and a half, and the length of the entire bone nine inches and a half. The contour of the articular head is transversely oval. The central part of the bone is occupied by a coarse cellular structure, one inch and a half in diameter, surrounded by dense osseous walls, three lines thick.

In the rich and instructive collection of Reptilian fossils, from the Cretaceous deposits in Cambridgeshire, in the possession of James Carter, Esq., M.R.C.S., of Cambridge, there are several vertebral bodies or "centrums" of the same species o *Plesiosaurus* which show the change of proportion in the breadth and depth of the

* Παχυς, thick, ὤμος, *humerus,* or arm-bone.

centrum which the vertebræ undergo as they pass from the region of the neck to that of the back, without corresponding alteration in the length of the centrum.

The following are dimensions of the most perfect specimens of these vertebræ:

	Anterior Cervical.		Middle Cervical.		Posterior Cervical.		Last Cervical.	
	In.	Lines.	In.	Lines.	In.	Lines.	In.	Lines.
Antero-posterior diameter, or length	1	9	2	0	2	0	1	10
Transverse diameter, or breadth	2	3	2	3	2	9	3	0
Vertical diameter, or height	1	9	2	3	2	6	2	7
Breadth of neural surface (middle)	—		0	2½	0	5	0	6
Breadth of neurapophysial pit	—		1	1	1	3	1	9
Breadth of costal surface	—		1	0	1	0½	—	
Height of ditto	—		0	10	1	0	—	
Distance between neurapophysial and costal pits .	1	0	0	9	0	7½	—	

The above dimensions show that whilst the centrums retain the length of two inches in the middle and towards the posterior parts of the long neck, they become shortened in the penultimate and last cervicals to the length of the smaller vertebra towards the anterior part of the neck; the difference, however, is but slight, and whilst an almost uniform length is retained, the vertebral centrums augment in height, and still more in breadth, as they approach the region of the back.

With the increased breadth of the centrum, there is a concomitant increase in tha of the rough depressions (T. XXI, figs. 3 and 4, *np*) for the articulation of the neurapophyses, and, at the same time, the bases of these vertebral elements become wider apart, and the breadth of the surface (ib. *n n*) supporting the neural axis, increases. This smooth surface which occupies the middle of the upper part of the centrum is contracted in the middle by the approximated neurapophysial pits, where there is on each side the orifice of the canal for the vertebral vein or sinus which traverses the centrum vertically. The lower openings of these canals are shown in T. XXI, figures 2 and 5, and their whole course is displayed in the fractured vertebra rrepresented in fig. 6, *c c'*.

The costal pits in the greater proportion of the cervical vertebræ present the form of a full transverse ellipse, as in T. XX, fig. 1, and are situated below the neurapophysial pit at a distance about equal to their own vertical diameter. They are nearer the posterior than the anterior surface of the vertebra, and thus differ in position as in shape from the costal surface in T. XIX, fig. 3, *pl*. As the cervicals approach the dorsal region the costal pit increases in vertical extent, assumes a circular form, and, as in all *Plesiosauri*, begins to rise towards the neurapophyses. The commencement of this

change in form and position of the costal pit, *pl*, is shown in T. XX, fig. 3, and its borders are here seen to be rather prominent. In none of the vertebræ has the costal pit presented the groove which, in most Plesiosauri, crosses it in the axis of the vertebra and divides it into two subequal parts. The articular ends of the centrum are slightly concave and are impressed by a circular pit at the centre; the peripheral margin is rounded off; it appears in the side view of the vertebra, fig. 3, T. XX, but not to such an extent as in *Plesiosaurus Bernardi*, T. XVIII, fig. 2. The lower apertures of the venous canals are closely approximated in all the cervicals except the most posterior ones, in which the canals diverge, as they descend, with a proportionate breadth between their lower outlets, *c' c'*, fig. 2, T. XXI. They are divided by a narrow ridge, as in fig. 5, in the ordinary cervical vertebræ, and are not situated in fossæ, as in the *Plesiosaurus Bernardi*, T. XVIII, fig. 4.

In the vertebra which I take to be the penultimate or antipenultimate cervical, the upper half of the costal surface has passed upon the base of the neurapophysis, and, from what remains upon the centrum, as at *pl*, fig. 5, T. XX, we may see that the surface has undergone a further change of form, and has exchanged the circular (as in fig. 3) for a vertically elliptical or oval figure.

In the centrum of the last cervical vertebra figured in T. XXI, figs. 1, 2, 3, the last trace of the costal surface is shown at *pl*, fig. 1. And I may here remark, that, as there is no definite natural distinction between the cervical and dorsal regions of the Plesiosaurus, the vertebræ in both supporting ribs, and the transition in the size, shape, and position of these being more gradual than in the Crocodiles, I have selected the arbitrary character of the impression of the costal articular surface, or any part of it, upon the centrum, as the character of the cervical vertebræ in the *Plesiosaurus*, and I count that to be the first dorsal in which the costal surface has wholly ascended upon the neurapophysis.

In T. XXI, fig. 7, one of the caudal vertebræ is figured showing the longitudinal channel, at the middle of the under surface, bounded by the ridges which terminate on the articular surfaces for the hæmapophyses: those surfaces are here worn away. The neurapophyses have coalesced with the centrum; and the ribs have also coalesced, forming the 'transverse processes' of this caudal vertebra.

Plesiosauroid Paddle. Table XVII.

The block of Chalk from the pit at Burham, in Kent, figured in Tab. XVII, includes parts of four digits of the same foot, the phalanges of which had the opposed ends flattened, and joined together by ligament, the whole forming part of the bony framework of a large fin, most resembling that of the *Plesiosaurus*. This fine specimen forms part of the rich Collection of Chalk-fossils belonging to Mrs. Smith, of Tonbridge

Wells. Had Cuvier's conjecture, that the extremities of the *Mosasaurus* resembled those of the *Plesiosaurus*, been supported by the evidence of such remains of extremities referable to *Mosasaurus* as have been discovered since his time, the present remarkable specimen from the Chalk Formations of Kent, might have been ascribed with some degree of probability to the great Lacertian of the Maestricht Chalk. But the evidence which has been adduced from the remains of extremities of the *Mosasaurus* from the Green-sand of New Jersey, in the United States,* is incompatible with the supposition that the phalanges of the *Mosasaurus* were united by flattened surfaces and syndosmosis. No remains of the Mosasaurus, so far as I know, have been discovered in the Chalk-pit at Burham, but some vertebræ of *Plesiosaurus* have been obtained from thence, including the fine one figured in T. XIX. In the specimen figured in T. XVII, fig. 1, three phalangeal bones, and part of a fourth are preserved in one digit, three phalanges in the adjoining digit, and one phalanx of the next, which, if it be in its natural relative position, would belong either to the outermost or the innermost digit; and this is the more likely, as the phalanx of a fourth digit is on the same parallel with the proximal phalanges of the two best preserved digits. In the paddle of the *Plesiosaurus* the phalanges of the three middle digits are on the same transverse parallel, whilst those of the outer and the inner digits are on a higher or more 'proximal' plane.

I conclude, therefore, that the phalanges marked *ii, iii,* and *iv,* are the middle ones of a pentadactyle paddle, and that the phalanx marked *v* has belonged to either the inner or the outer terminal digit. If the fragment of bone that closely adheres by a flat surface to the proximal end of the phalanx *ii,* belong to the small carpal bone which articulates with the second digit in the paddle of the *Plesiosaurus*, we must consider the phalanx to which it is attached, and the two parallel phalanges, as appertaining to the proximal series: but that fragment may be a remnant of a proximal phalanx itself. The proximal surface of the three phalanges is slightly concave: the shaft of the phalanx is thick and strong; rather compressed from before backwards; gradually contracting to the middle part. Their substance presents a coarse cancellous texture throughout, with the cells or intervals widest at the middle of the bone. The parts being represented of the natural size, it is unnecessary to specify the dimensions of the phalanges. If the length of the proximal phalanx be taken with the compasses in digits *iii* and *iv,* it will be found that the two following phalanges progressively decrease in length. On the supposition that the phalanges of these digits are the first, second, and third, we may estimate the length of the entire paddle, according to the proportions of that of the *Plesiosaurus Hawkinsii,* at sixteen inches; which would accord with the proportions of the vertebra of the Plesiosaurus from the same pit, figured in T. XIX.

* Quarterly Journal of the Geological Society, Jan., 1849, See also, ante, pp. 37—39.

In the instructive Collection of THOMAS CHARLES, Esq., of Maidstone, is part of a single digit of the paddle, T. XVII. fig. 2, of apparently the same species of *Plesiosaurus.* It includes three phalanges, and part of a displaced small phalanx of an adjoining digit. In comparison with the more perfect paddle in Mrs. Smith's collection, I regard the phalanges in the present specimen as being the third, fourth, and fifth of their digit.

Genus, ICHTHYOSAURUS.

If the investigation of the fossil remains of the Chalk-beds had been undertaken by the Comparative Anatomist, without previous knowledge of the fossils of the lower secondary formations, he would have perceived in the teeth which form the subjects of T. XXIV, characters not only specifically, but generically, distinct from any of the teeth that have been previously described and figured in the present monograph. The thick conical crown covered by enamel, raised into numerous longitudinal ridges, would have offered, it is true, a repetition of the general character of that of the teeth of *Polyptychodon;* but the continued expansion of the base or fang of the tooth, and the coarser longitudinal ridges and grooves with which most of the surface of that part is sculptured, would be a peculiarity distinguishing the present from any of the previously noted teeth from the Cretaceous or Tertiary series, and still more so from the teeth of any known existing Reptile. It is only, indeed, those of the largest Crocodiles or Alligators that can compete with the present fossil teeth from the Chalk-formations in point of size; and the crowns of these, as in the teeth of the *Polyptychodon,* differ from the teeth of the *Crocodilia* in the absence of the two opposite ridges, forming or indicating the edges of the crown; whilst their base also differs from that of the Crocodile's tooth in the structure above defined,—a difference which becomes more manifest when a section of that part is made, demonstrating that the expanse of the fang is due to the unusual thickness of the osseous external crust called 'cement.' The Anatomist, I say, would be justified in deducing from these characters the generic distinction of the Reptile to which they had belonged, but he could have formed no suspicion of the truly extraordinary modifications of the entire reptilian organisation that had been associated with such generic modifications of the teeth. Such fossil teeth, having a conical, enameled, and commonly striated crown, offering a considerable range of variation in its proportions, and supported by an expanded, usually solid, and coarsely-grooved fang, covered by a thick coat of cement, have been recognised, since the publication of Sir Everard Home's Paper 'On the Remains of an Animal linking the class of Fishes to that of the Crocodile,' published in the Philosophical Transactions for 1814, as belonging to that genus of animal to which Home gave the name of *Proteosaurus,* but to which Naturalists have concurred in applying the more classically

constructed and appropriate name of *Ichthyosaurus,* suggested for it by the estimable and accomplished keeper of the Mineralogical Department of the British Museum, CHARLES KÖNIG, K.H., F.R.S.

Remains of species of *Ichthyosaurus* are found in secondary strata from the Chalk down to the Muschelkalk, and most abundantly in the Oolite and Lias. In my 'Report on the British Fossil Reptiles,' I recorded the discovery of "portions of the lower jaw with teeth of a large species of *Ichthyosaurus* from the lower Chalk between Folkstone and Dover, which was closely allied to the *Ichthyosaurus communis.* And in the description of the Fossil Reptilia in Mr. Dixon's work 'On the Geology of Sussex, some teeth from the Chalk of Kent, now preserved in the Museum of William Harris, Esq., F.G.S., are figured in T. XXXIX, fig. 10, where they are stated to belong to the genus *Ichthyosaurus,* and to correspond so closely in form and size with those of the *Ichthyosaurus communis,* that I did not presume, in the absence of any knowledge of the skeleton, to pronounce them to belong to a distinct species.

I have since been favoured with the opportunity of studying and comparing the required parts for yielding more satisfactory characters, and have arrived at a conviction of the distinction of the species of Ichthyosaur of the Chalk-epoch from that of the Lias, which it most resembles in the general shape and proportions of the teeth, a distinction first recognised by James Carter, Esq., M.R.C.S., of Cambridge, who proposed for the species the name of *Ichthyosaurus campylodon,* at the 'Meeting of the British Association' at that University in 1846, on the occasion of the exhibition of some fine remains of the species obtained by him from the Lower Chalk, in the vicinity of Cambridge, in 1845. Before describing these remains, I shall give an account of the additional specimens from the locality whence I derived the first evidence of the presence of remains of the *Ichthyosaurus* in the Cretaceous strata.

ICHTHYOSAURUS CAMPYLODON, *Carter.* Lower jaw, Tab. XXIII.

In the operations upon the Chalk-cliffs connected with the Dover Railway, a considerable proportion of the lower jaws and fragments of the ribs of a large *Ichthyosaurus* were brought to light; they were dislodged from the hard gray chalk at the end of the Round Down Tunnel, about two miles and a half from Dover, under the cliff, four feet from the beach beyond "Shakespeare's Cliff," towards Folkestone.

The specimens are now in the collection of H. W. Taylor, Esq., of Brunswick Place, Brixton Hill, to whose kindness I am indebted for the present opportunity of describing and figuring them.

The principal portion consists of four coadaptable fragments of the left ramus of the lower jaw, including nearly the whole of the dentary piece, and fragments of the splenial and angular pieces, the whole measuring two feet seven inches in length, but

without the natural anterior termination; and wanting all that extensive hinder part of the ramus formed by the angular and surangular pieces. The inner alveolar plate of the dentary is broken away; but the vertical diameter of the outer part of the bone, from being 2 inches 6 lines at the hinder end, gradually decreases to 1 inch 9 lines at the fore part. A few teeth have been cemented to the alveolar plate in the anterior fragments, and perhaps in the places near which they were found, for numerous scattered teeth of the *Ichthyosaurus campylodon*, and doubtless of the same individual as the jaws, were exposed in the fragments of the Chalk rock containing those parts.

The outer surface of the dentary bone, T. XXIII, fig. 1, is convex, the inner surface at the part where the second joins the third fragment, about 1 foot 6 inches from the anterior end, is divided into two longitudinal channels by the base of the inner alveolar wall; which base is perforated lengthwise by the dental canal. As we trace this part of the dentary backwards, the alveolar groove progressively shallows and diminishes, and the lower groove widens and increases; the section of the dentary at the back part of this fragment, two feet from the fore end of the whole portion of the bone preserved, presenting a sort of hour-glass form, the upper and under portion being connected by a very thin plate. The form of the section displayed at the fractured end is given in T. XXIII, fig. 1*. The coarser central osseous texture appears to have been included within a thin, dense, exterior crust, about a line in thickness, and the same crust surrounds the canal *c*. The outer surface of the dentary piece shows a shallow groove about two thirds of an inch below the outer alveolar border, into which groove the several vascular foramina open which are continued from the canal, fig. 1 *c*.

The portion of the right ramus of the same lower jaw, T. XXIII, fig. 2, includes the termination of the splenial pieces, and the commencement of the symphysis and includes an extent of the dentary piece, 32, measuring one foot three inches in length. The vertical diameter of the dentary at the hinder fractured end, fig. 2*, is three inches, and at the front end, fig. 2**, is two inches two lines. The inner alveolar plate is sent off about an inch below the upper border of the thick outer plate; and forms the floor of the groove before it rises to form the inner wall; it slightly increases in thickness in forming the rounded border of that wall; the diameter of the floor of the socket is three lines. The depth of the socket is two inches three lines, its breadth is ten lines and a half. Portions of both splenial bones, somewhat dislocated, are shown at 31, 31.

The cavity in the dentary beneath the alveolar wall is reduced to a mere groove midway between the fractured ends, with the exception of which the whole of the now flattened inner surface of the dentary is in contact with its fellow, forming the strong and long symphysis menti. At the fore part of the fragment the alveolar groove is reduced to a depth of eleven lines, and a breadth at its outlet of nine lines. One of the transverse canals is exposed at the anterior fracture, which passes from the inner longitudinal canal to the outer groove. Wherever the bone is broken, that modification

of its outer surface is shown, which gives it the appearance of forming a crust about a line in thickness, of a different texture from the rest of the bone.

The fragment, T. XXIII, fig. 3, is a portion of the right premandibular bone, showing a cast of the dental vasculo-nervous canal, and the outlets terminating at the orifices on the outer side of the bone.

The teeth, supposing them to have been correctly restored, decrease in size, as in the *Ichthyosaurus communis*, near the anterior end of the dentary piece.

The largest tooth in this portion of the jaw, placed one foot from the anterior end, has a crown eleven lines in length, straight, conical, rather obtusely pointed, five lines and a half in diameter, with numerous, not very sharp, but close-set ridges, narrowing as they approach the summit, and subsiding before they attain it. The cement-covered base continues to expand as it descends, with a smooth exterior for about one third of its extent from the crown, and with coarse longitudinal striations or wrinkles over the rest of its extent. The surface of the base in most of the teeth, like the surface of the bone, is coated by a firm crust, sparkling with minute crystals of pyrites. In the attempt to remove this coating, the parts have been more or less injured, so that the precise character of the external markings, and original shape of the thickened fang, cannot be ascertained. The transverse section of the crown of the tooth is circular at its apical half, but widens into a full ellipse towards the base; that of the smooth beginning of the base is a modified ellipse, which in the rougher and more expanded part of the base, seems to take on a subquadrate form.

The teeth differ in size at different parts of the jaw; in the first or foremost of the series the crown of the tooth is only four lines in length in the lower jaw, and it gradually increases to eight and ten lines in length,—the total length of the longest tooth being two inches and a half. Some of the scattered teeth adherent to the present fragments having very short and thick crowns. In fig. 4, the crown is as wide at its base as it is long: a portion of the thick cement has been removed from the fang just below the crown, and exposes the grooved exterior surface of the dentinal base of that part of the tooth.

In the *Ichthyosaurus communis*, the teeth of which most resemble those of the present species from the chalk, the crown of the tooth tapers more gradually to the apex; and the enamel ridges are immediately continued upon broader rounded ridges of the cement-covered fang, which become more strongly marked as the fang recedes from the crown, and are divided by deep grooves, giving a fluted character to the base of the tooth, which is proportionally less expanded, and retains more of the circular form in transverse section. (See T. IV, fig. 17.)

In the few more or less imperfect teeth of the *Ichthyosaurus* from the chalk, which I had seen whilst drawing up, in 1838, my Report on 'British Fossil Reptiles,' the differences above specified were not manifested so clearly as in the more numerous and complete examples which have since been submitted to me. The smooth exterior

of that part of the fang next the crown, in the *Ichthyosaurus campylodon*, is due to a thick coat of cement; the dentine so covered shows a fluted character, only differing from that of the teeth of the *Ichthyosaurus communis* in being more regular and somewhat finer. This is shown in T. XXIII, fig. 4.

Not any of the detached teeth discovered with the above-described portions of jaw present any well-marked curvature of the base. The characteristics of the teeth of the *Ichthyosaurus campylodon* are best displayed in those specimens that have been obtained from the cretaceous deposits in Cambridgeshire.

Teeth of Ichthyosaurus campylodon. Tab. XXIV.

The detached teeth from the Cambridge Chalk and Green-sand present two modifications of form: the majority are straight, the rest curved, chiefly owing to a slight inward bending of the thickened fang. These latter have been proved to come from the lower jaw, and the curvature relates, as Mr. Carter has well remarked, to the more oblique direction outwards of the alveolar groove in that jaw, which is compensated by the curvature of the teeth, the crowns of which are thereby brought into more direct apposition with the teeth above.*

The enameled crown in all the teeth (figs. 1, 2, 6 *c*) is a cone, short and thick in the largest teeth, with a circular or very full elliptical transverse section; it is a longer and narrower cone in most of the smaller teeth. The ridges of the enamel are numerous and fine, not always of equal thickness; the intervening grooves are rather narrower than the ridges. In some teeth, shorter and narrower ridges are seen in the basal intervals of the longer ridges: in other teeth the ridges are thicker at the base of the crown, and are occasionally impressed or divided there by a shorter longitudinal groove. All the ridges subside before they reach the apex of the crown, which is smooth. The enamel terminates at the base of the crown by a thin well-defined border. The tooth continues to expand beyond this border, and, for an extent varying from one third to one fifth of the entire fang. The surface is smooth; not any of the longitudinal furrows or ridges of the enameled crown being continued upon that part of the cement-covered fang. In a few teeth, the base of the crown is well defined, as Mr. Carter has remarked, by an annular projection, T. XXIV, figs. 3 and 4. The rest of the base or fang of the tooth, beyond the smooth part, presents coarse longitudinal ridges and grooves, is much expanded in most of the teeth, and in many it presents, as in the tooth figured and described by Mr. Carter,† a square shape. This character is best marked in the straight teeth from the upper jaw; it arises out of the progressive growth of the osseous cement of the fang, which seems to have

* London Geological Journal, vol. i, p. 9.

† Loc. cit., p. 8, figs. *a* and *b*.

been only checked by the resistance of the alveolar walls on the outer and inner sides of the tooth, and by the contiguous teeth before and behind. Thus, by this thickening of the fang, the teeth must have become wedged together in the common alveolar groove, and the absence of partitions completing the sockets must have been in some measure compensated by this firm impaction. This is shown in the part of the fractured jaws. (Tab. XXVI, fig. 2.)

Figs. 3 and 4, T. IV, give two views of a portion of the alveolar groove with one tooth thus squarely wedged in its place, part of the adjoining tooth on one side, and part of the socket on the other, in which a thin bony partition had been formed for a short extent of the base of the tooth. The extent of the square root in the direction of the long axis of the jaw, fig. 4, is commonly greater than the transverse diameter of the same root, fig. 3. The tooth is never wholly consolidated even in this fully developed state of the fang: a remnant of the uncalcified pulp has always been retained in the central dentinal part of the enlarged fang, after the crown has been completed. This is shown in the fractured specimen, fig. 5, in which the square fang beyond the cavity, *o*, is one solid mass of coarse cement; and more clearly in the transverse section, fig. 6, in which *c* is the cement, *d* the dentine, and *a* the pulp-cavity. The view given at fig. 6′ shows the consolidated base of the thickened fang,—a character by which the teeth of the Ichthyosaurs differ from those of almost all other Saurians, and especially from the Crocodiles, in which the base of the tooth always remains widely open.

Notwithstanding, however, the resistance which must be opposed by the thickened and consolidated root of the tooth of the Ichthyosaur, it is affected by the germ of the succeeding tooth in the same way as in the *Crocodilia*. I have seldom, indeed, seen the process better illustrated than in a series of the teeth of the *Ichthyosaurus campylodon* in Mr. Carter's collection, obtained from the Chalk in the neighbourhood of Cambridge.

Fig. 7 is a tooth with a thick, straight, square fang; probably, therefore, from the upper jaw, which shows on one of the broader sides of the base a shallow elliptical depression, *o*. This is caused by the progressive absorption excited by the pressure of the soft matrix of the successional tooth which was in the course of development at the angle of the alveolar groove on the inner side of the base of the tooth in place. In the Ichthyosaur's tooth the absorption causes a simple excavation in the substance of the thick cement; but in the Crocodile's the same process speedily penetrates the thinner wall of the large cavity in the base of the tooth, as is shown in the figure of that of an Alligator (fig. 11), where a circular aperture is the result of the pressure. As the new tooth of the Ichthyosaur grows, the thick cement of the old tooth yields, and the reduced pulp-cavity in the centre of the fang is penetrated, as is shown at fig. 8, *o*, where the absorbent process has extended nearly across the whole solid base of the fang, fig. 8′. In fig. 9 the germ of the tooth is preserved, which has penetrated

the breach so excavated; and as both this and the preceding tooth (fig. 8) are from the lower jaw, the direction in which the fang is bent demonstrates that the germs of the new teeth were developed from the inner angle of the bottom of the alveolar groove, and affected the inner side of the base of the fully formed teeth, as in the Crocodiles. In fig. 10 the crown and the smooth beginning of the fang of the successional tooth have been completed, and it is seen enclosed by part of the debris of the old tooth which it is about to replace. As in all young teeth, the crown is a thin shell of the first-formed layers of dentine, with a thin coat of enamel, the ridges of which seem not to have been quite completed.

The teeth of the Ichthyosaurus are smaller at the two extremes than at the middle of the series in both jaws; and some modifications of form are presented in these teeth, which do not, however, overpass the recognisable limits of the specific characters.

Fig. 13 is a tooth probably from the back part of the series in the upper jaw, in which the crown is less broad at its base and relatively longer than in the large teeth from the middle of the series; the rough expanded fang presents in transverse section a long ellipse, with its angles truncated, making but a slight approach to the quadrate figure of the fang of most of the larger teeth; but in the fine striation of the conical enamelled crown, in the smooth tract of unenamelled fang which precedes the roughly striated expanded portion, and in the degree of expansion of this part, all the distinctive characters of the *Ichthyosaurus campylodon* are preserved.

Figure 14 is an incompletely formed tooth from the opposite end of the dental series, in which the enamelled crown is unusually short and thick; but the smooth surface of the portion of the fang which has been formed, which continues to expand to the widely open pulp-cavity, gives the character of the same species as fig. 13.

In fig. 15, from the Upper Green-sand, we have a tooth in a more advanced stage of formation: the roughened thickened part of the base has begun to be added; but this is still widely open, as is shown in fig. 15′.

In Figure 16, a greater proportion of the rough expanded fang is completed, and the basal outlet of the pulp-cavity is beginning to be encroached upon: but in these young teeth the cement has not increased in such quantity as to be moulded into the square form that is so characteristic of the old teeth.

Jaws of the Ichthyosaurus campylodon, from the Cambridge Chalk. Tables XXV and XXVI.

The portions of the upper and lower jaws discovered with the teeth above described, and containing several teeth of the same character *in situ*, are, as their possessor, Mr. Carter, truly describes, the most characteristic relic of the Ichthyosaurian genus hitherto obtained from the Cretaceous Formations.

The portion of the upper jaw includes an extent of two feet of the premaxillary

bones, including at the back part about three inches of the exposed, and apparently pointed terminations of the nasal bones (T. XXV, fig. 2, 15.) These, however, extend much further forwards than they appear to do externally, their anterior ends being overlapped by the premaxillaries, 22. The breadth of the premaxillaries at the fractured hinder end of this specimen is $5\frac{1}{2}$ inches, at the distance of one foot from that fractured end it is $3\frac{1}{2}$ inches, and the decrease seems to have been rather more gradual in advance of this part. The total length of the jaws from the point of union of the premaxillaries above the nasals, may therefore be estimated at about three feet.

The breadth of each nasal, where they dip beneath the premaxillaries, is one inch three lines: the upper surface presents a longitudinal furrow midway between the margins of the bone, into which furrow a longitudinal ridge at the under surface of the premaxillary fits, thus strengthening the union between the two bones. The nasal bone forms a parallel ridge, or angular projection, from its own under surface, which divides the inferior concavity into two parts, the median and broader concavity being somewhat angular in form. The actual pointed ends of the nasals are visible at a fractured surface, (T. XXVI, fig. 2, 15,) nine inches in advance of the point where they are concealed by the median junction of the premaxillaries: their section here presents the form of a curved lamina of bone, thickest at its median border, and half an inch in breadth, and this may be traced beneath the fractured portion of the premaxillary three inches further forwards.

The breadth of the nasal cavity at the back part of the fractured end, (T. XXVI, fig. 1,) is rather more than two inches: at the anterior fracture, fig. 2, it is reduced to ten lines.

The median borders of the premaxillaries, (T. XXVI, fig. 1, 22,) before their junction above the nasals, (ib. 15,) are about one line thick, and the bone increases to a thickness of three lines, above the part where it sends off, inwards and downwards, the inner alveolar border, (ib. *al,*) which is at a distance of an inch and three fourths from the upper median border. On the outside, opposite the origin of the inner alveolar plate, the premaxillary is traversed by a straight longitudinal groove, (T. XXV, fig. 1, *g,*) four lines in breadth, which contracts, as it advances forwards. The outer alveolar plate, (T. XXVI, fig. 1, *a,*) increases in thickness to six lines, and terminates below in a convex border. The inner alveolar plate, (ib. *al,*) forms the chief part of the arched roof of the upper dental groove, and has there scarcely a line in thickness; but as it descends, it rapidly gains a thickness of five lines at its inferior convex border. There is a slight solution of continuity between the arched and descending portions of the inner alveolar plate, (ib. *al',*) at the hinder fractured end of the specimen, and the descending plates might at first sight be taken for the palatine bones: but these, in other *Ichthyosauri,* are vertical plates, which lie parallel with, and on the inner side of the descending alveolar plate of the premaxillary, and do not reach so far forwards as where the nasals are wholly overlapped by the premaxillaries. The inner alveolar

plate descends eight lines lower than the outer one, and the outlet of the alveolar groove has a corresponding oblique aspect downwards, and a little outwards: the breadth of the groove at the outlet is 1 inch 2 lines: the depth of the groove, to the inner border, is 1 inch 6 lines: the breadth of the alveolar part of the premaxillary, including the plates, is 2 inches and a half. At the anterior fractured end of the left premaxillary, (T. XXVI, fig. 2, 22,) ten inches in advance of the hinder fracture, the vertical diameter of the bone is 2 inches 10 lines, the breadth of the lower alveolar part is 1 inch 9 lines, the depth of the alveolar groove is 1 inch 5 lines, the breadth of its outlet 1 inch 1 line. Here the two premaxillaries are in contact at the upper borders, which have progressively increased, after overlapping the nasals, to a thickness of 7 lines, The inner alveolar plate is sent off about half an inch below the upper border, extending inwards and downwards, and dividing the nasal from the alveolar groove, then descending, in contact with the same plate of the opposite premaxillary, for about an inch of vertical extent: the thickness of the plate near its origin is 3 lines, whence it increases to 7 lines at its lower rounded border, ib. *al''*. The elliptical area of a canal, 4 lines in diameter, *o*, is exposed above the origin of the inner alveolar plate. The narrow exterior groove, *g*, sinks 3 lines into the substance of the bone, and slightly expands towards its bottom. The outer groove and the inner canal communicate by transverse anastomosing channels at certain parts.

The whole of the upper surface of the premaxillaries forms a smooth arch of bone, describing in transverse section a semicircle, and impressed only by the longitudinal groove each side, for the lodgement of a vessel on and probably also a branch of the fifth pair of nerves.

The portion of the lower jaw consists of the dentary and splenial pieces,* both dislocated, the former slighly. At the back part of the left ramus, (T. XXVI, fig. 1,) the lower border of the splenial, (ib. 31,) has been pressed inwards and downwards from that of the dentary, (ib. 32,) and slightly rotated so as to incline its inner vertical wall outwards, where it is pushed into the groove or concavity of the dentary, which it naturally closes, applying itself to the side of the inner alveolar plate of the dentary. The right splenial, (ib. 31,) has been still more displaced, its lower border being pushed against the base of the inner alveolar plate of the left ramus.

Both splenials are exposed at the anterior fracture of the rami, (T. XXVI, fig. 2,) six inches in advance of the preceding, the right being here, also, above the left, and removed from its own ramus to contact with the base of the inner alveolar plate of the left ramus. The vertical diameter of the splenial, which is two inches at the hinder fractured part, has diminished to little more than one inch at a distance of five inches

* See the Cut, fig. 9, p. 17, of the 'Monograph,' Part ii, *Crocodilia* and *Ophidia*, of the London Clay, in which the different pieces of the complex lower jaw of Reptiles is figured: and where 29 is the "articular," 29' the "surangular," 30 the "angular," 31 the "splenial," 31' the "complemental," 32 the "dentary," in the Alligator.

in advance of this. The splenial has the same shape as in other *Ichthyosauri,* being a longitudinal plate, with its lower margin bent outwards at a right angle; this margin forms the lower border of a great extent of the ramus, underlapping the dentary at the situation of the posterior fracture, which is a little prior to the junction of the two rami forming the symphysis; it is withdrawn to the inner side of the dentary at the anterior fracture. The ascending or vertical plate of the splenial forms the largest part of the bone, and is much thicker than in the Crocodile with a jaw of the same depth: its transverse diameter in the present Ichthyosaur is 3 lines.

The dentary is a long bone which, at the hinder fractured part, (T. XVI, fig. 1, 32,) appears as if it were folded lengthwise twice upon itself, forming a sigmoid transverse section; but the outer part of the bone increases in thickness as it advances forwards, and the inner alveolar wall presents, at the anterior fracture, more the appearance of an accessory plate or process sent off from the inner side of the body of the bone. The vertical diameter of the dentary pieces is 2 inches 3 lines.

The outer part of the dentary at the hinder fracture is 6 lines in thickness, smooth and convex on its outer side, which is traversed by a longitudinal groove, *g,* which also slightly narrows as it advances. The alveolar plate is continued downwards and inwards at an angle of about 50°, diminishing in thickness as it descends, and again increasing after it has risen, to form the inner wall of the alveolar groove. The depth of the groove is 1 inch 5 lines; its width is 1 inch. At the anterior section, 5 inches in advance, (T. XXVI, fig. 2,) the alveolar groove (*ac*) has contracted to a diameter of 8 lines, and is 1 inch 2 lines in depth; the inner alveolar wall, (*al,*) has increased in thickness.

The lower jaw, in the present fine fragment of skull, appears to have been broken across just anterior to the meeting of the two rami, where they form the symphysis.

What is wanting in the specimen of the *Ichthyosaurus campylodon* in Mr. Carter's collection to give, *ex visu,* the proportions of the jaws of that species, is, in great part, supplied by the fragments from Mr. Taylor's collection, which had been previously discovered in the Grey Chalk near Dover.

The hinder end of the portion of the left ramus in that specimen, which measures 2 feet 7 inches in length, has been broken away from the part which corresponds with the front end of the portion of the same bone in Mr. Carter's specimen, and this end is nearly 1 foot distant from the hindmost part of the same specimen. We thus gain an extent of jaw by this addition of nearly 3 feet, and at least 1 foot more would be required to complete the whole length of the jaw.

Owing to the partial dislocation of the rami, the aspect of the alveolar groove is more outwards than is natural; but in the proper relative position it is turned more obliquely outwards than that of the upper jaw, and the roots of the lower teeth, as Mr. Carter has well remarked, present a curvature which compensates for the obliquity of this alveolar groove, and gives a more vertical direction to their crowns.

This characteristic of the present species is well shown in the group of upper and lower teeth preserved on the right side of the present instructive fragment of the skull, (T. XXV and T. XXVI, fig. 2.) It includes, in an extent of 6 inches and 9 lines, six teeth of the upper jaw; and, in an extent of 4 inches and a half, four teeth of the lower jaw. Besides the teeth which have preserved nearly their natural positions in respect of each other, there are three or four displaced teeth or fragments of teeth. Of the four teeth of the lower jaw, the three largest, while they have kept nearly their natural position to the teeth above, have slipped out of the groove of the lower jaw during its downward displacement, instead of being separated to the same extent from the upper teeth. In the lower jaw of the Cachalot, where the teeth are lodged in a wide groove, and with the alveoli incompletely developed, they are easily dislodged when decomposition has commenced, and may be stripped away with the firm gum, to which the necks of the teeth adhere more strongly than their fangs do to the rudimental sockets.

The first of the six teeth of the upper jaw is completely formed, and shows the quadrate root a little compressed in the transverse direction. The rough part of the fang is that which is embraced by the sides of the alveolar grove; the smooth portion was probably surrounded by a soft slimy gum as far as the enamelled crown. The tooth opposed to this in the lower jaw, and the crown of which passes, as usual, external to it, is a young tooth, with the fang as yet incompletely formed and rounded: its inferiority of size to the tooth above depends on this circumstance. The second tooth above is not so far advanced in growth as the one which precedes or the four that follow it; the crown and part of the fang of the last, *m*, of these are broken away, and expose the germ of the young tooth, *t*, which had penetrated its cavity and was about to displace it. The curve of the rough expanded fangs of the lower teeth is well exhibited in the last two of these teeth.

The teeth of the *Ichthyosaurus campylodon* are large in proportion to the slenderness of the elongated jaws, and offer, in this respect, a great contrast with those of the *Ichthyosaurus tenuirostris:* they are even larger in proportion than the teeth of the shorter and thicker jawed *Ichthyosaurus communis* and *Ichthyosaurus lonchiodon,* and both the proportions and the form of the teeth determine the specific distinction of the present *Ichthyosaurus* of the Chalk and Green-sand from any of the known species from the older secondary strata. But there is no modification indicative of a departure from the generic characteristics of the great Fish-lizard: on the contrary, so far as these are manifested by the structure of the jaws, especially the undivided alveolar groove, by the great proportional size of the premaxillaries, and by the thickly cement-covered fangs of the teeth, these characters are rather in excess, and the last of the Ichthyosaurs, far from progressing towards any higher and later form of reptile, might be cited as a type of its peculiar genus.

VERTEBRÆ OF ICHTHYOSAURUS CAMPYLODON. T. XXII.

Had no other part of the *Ichthyosaurus* been discovered in the Chalk Formations than the centrum of a vertebra, that alone would have sufficed to convince the investigator, who had commenced his researches by descending from the more recent to the older Formations, that some marine Saurian had existed totally distinct from any other Reptile which he might have met with in the chalk; if, indeed, a vertebra so far departing from those of the *Reptilia* in general had not been mistaken for the vertebra of a Fish. The most fish-like character of the Ichthyosaurus is the deep concavity of both articular extremities of the centrum, fig. 3, and the shortness of the vertebra, fig. 1, as compared with its breadth and height, fig. 2, in which proportion it resembles the vertebræ of the shark tribe. But the peripheral non-articular or free surface of the vertebra is smooth and entire: the articular depressions for the neurapophyses are shallow, and those for the ribs are situated on either one or two tubercles on each side of the centrum. Such pair of costal tubercles would alone suffice to distinguish the vertebra of the Ichthyosaurus from the biconcave vertebra of any fish. All the general characters of the Ichthyosaurian vertebræ are manifested by the specimen figured in T. XXII.

It was discovered in the same mass of grey chalk at the base of Shakspeare's Cliff as the jaws and teeth figured in T. XXIII, and forms with these part of the collection of W. H. Taylor, Esq. It corresponds in its dimensions with those fine fragments of jaw, and might well have formed part of the vertebral column, which supported a head four feet in length.

The substance of the bone is decomposed, and the surface studded with firmly adherent pyritic matter. It appears to have come from the base of the tail, where the costal tubercles become single. The surface of the articular concavity has the gentle undulating disposition, convex at the periphery, before the deeper central concavity is scooped out, as shown in the section, (T. XXII, fig. 3,) which is common to some other species of Ichthyosaurus; but no specific character could have been deduced from this fragment of the skeleton.

The vertebra figured measures 4 inches vertically across the articular concavity; and 1 inch 10 lines longitudinally across the side. A smaller vertebra from the middle of the tail measures $3\frac{1}{2}$ inches transversely, and $1\frac{1}{2}$ inch in antero-posterior extent. The concavity deepens rather suddenly towards the centre.

Three more or less mutilated bodies of vertebræ, having similar proportions to those of the *Ichthyosaurus campylodon* from the Dover Chalk, have been obtained from the Upper Green-sand near Cambridge, where they are also associated with teeth of the same species. They are preserved in the cabinet of James Carter, Esq., M.R.C.S.

In the *Ichthyosaurus tenuirostris*, the length of the lower jaw equals at least fourteen times that of the vertical diameter of the centrum of an anterior caudal vertebra; in the *Ich. communis* and in the *Ich. lonchiodon* eleven times; in the *Ich. intermedius* ten times. The jaws of the *Ichthyosaurus campylodon* must have approached more nearly to the proportions of those of the *Ich. tenuirostris*, than the other species above named, and it is not unlikely that the lower jaw was thirteen times the length of the vertical diameter of an abdominal or anterior caudal centrum.

Assuming such proportions, we may reckon the lower jaw to have been upwards of four feet in length; and this calculation accords with that founded upon the proportions of the fragments of the lower jaws above described.

One of the masses of chalk contains portions of several ribs, the longest being about ten inches in length; the transverse section of these portions of rib is a regular full ellipse, the fractured end of one of the least mutilated is 9 lines in its long diameter, 6 lines in its short diameter; but some parts of the ribs are 1 inch in breadth. Not any of these fragments show the opposite longitudinal impressions that characterise some of the ribs in the *Ichthyosaurus communis*.

ORDER. *PTEROSAURIA*, Owen.

Genus—PTERODACTYLUS, *Cuvier*.

The honour of having first made known the existence of remains of *Pterodactyles* in the Chalk belongs to the able Secretary of the 'Palæontographical Society,' JAMES SCOTT BOWERBANK, Esq., F.R.S. This indefatigable Collector had the good fortune to receive, in 1845, from the Chalk of Kent, the characteristic jaws and teeth, with part of the scapular arch and a few other bones of a well-marked species of *Pterodactylus*, and the discovery was briefly recorded in the 'Proceedings of the Geological Society of London' for May 14th, 1845,* with an illustrative plate. Mr. Bowerbank concludes his Paper by referring to a large fossil wing-bone from the chalk, which I had previously figured and described in the 'Geological Transactions,'† and remarks that "if it should prove to belong to a *Pterodactyle*, the probable expansion of the wings would reach to at least eight or nine feet. Under these circumstances," he says, "I propose that

* The author there states that the specimens were "obtained from the Upper Chalk of Kent:" Mr. Toulmin Smith, in his able paper "On the Formation of the Flints of the Upper Chalk" in the 'Annals of Natural History,' vol. xx, p. 295, affirms that no Upper Chalk exists in the localities whence those specimens came. They are from the Middle Chalk.

† Second Series, vol. vi, 1840, pl. 39, fig. 1.

the species described above shall be designated *Pterodactylus giganteus*," (loc. cit., p. 8.) Subsequent discoveries and observations have inclined the balance of probability in favour of the Pterodactylian nature of the fossils to which Mr. Bowerbank refers.

These fossils are not, indeed, amongst the characteristic parts of the flying reptile; one is the shaft of a long bone exhibiting those peculiarities of structure which are common to birds and Pterodactyles; the other shows an articular extremity which, in our present ignorance of the different bones of the Pterodactyle, has its nearest analogue in the distal trochlea of the bird's tibia. These two specimens, which are figured in the above-cited volume of the 'Transactions of the Geological Society,' Pl. 39, figs. 1 and 2, were, in fact, as I acknowledged in the Memoir, read April 26th, 1840, transmitted to me by the Earl of Enniskillen and Dr. Buckland, as being the bones of a bird (p. 411), and my comparisons of them were limited to that class.

The idea of their possibly belonging to a Pterodactyle did occur to me, but it was dispelled by the following considerations. The act of flight—the most energetic mode of locomotion—demands a special modification of the vertebrate organisation, in that sub-kingdom, for its exertion. But in the class *Aves*, in which every system is more or less adapted and co-adjusted for this end, the laws of gravitation seem to forbid the successful exercise of the volant powers in species beyond a certain bulk; and when this exceeds that of the Condor or Albatross, as, for example, in the Cassowary, the Emeu, or the Ostrich, although the organisation is essentially that of the vertebrate animal modified for flight, flight is impossible; and its immediate instruments, to the exercise of which all the rest of the system is more or less subordinated, are checked in their development, and, being unfitted for flight, are not modified for any other use. There is, perhaps, hardly a more anomalous or suggestive phenomenon in nature than a bird which cannot fly! A small section of the *Mammalia* is modified for flight; but the plan of the organisation of that warm-blooded class being less directly adapted for flight than that of birds, the weight and bulk of the body, which may be raised and transported through the air, are restricted to a lower range; and the largest frugivorous Bat (*Pteropus*) does not exceed the Raven in size. The Reptilian modification of the vertebrate type would seem to be still less fitted for any special adjustment to aerial locomotion; and, in the present day, we know of no species of this class that can sustain itself in the air which equals a sparrow in size; this species, moreover, the little *Draco volans*, sails rather than flies, upborn by its outstretched costal parachute in its oblique leaps from bough to bough.

Of the remarkable Reptiles now extinct, which, like the Bats, had their anterior members modified for plying a broad membranous wing, no species had been discovered prior to 1840, which surpassed the largest of the *Pteropi*, or "Flying-foxes," in the spread of those wings, and there was *à priori* a physiological improbability that the cold-blooded organisation of a Reptile should, by any secondary modification, be made

to effect more in the way of flight, or be able to raise a larger mass into the air, than could be done by the warm-blooded mammal under an analogous special adaptation.

When, therefore, the supposed bird's bone, T. XXX, fig. 4, was first submitted to me by Dr. Buckland, which, on the Pterodactyle hypothesis, could not be the humerus, but must have been one of the smaller bones of the wing, its size seemed decisive against its reference to an animal of flight having a cold-blooded organisation. The subsequent discovery of portions of the skull of the Pterodactyles, figured in T. XXVIII, shows that the manifestations of Creative power in past time surpass the calculations that are founded upon actual nature.

It is only the practised Comparative Anatomist that can fully realise the difficulty of the attempt to resolve a Palæontological problem from such data as the two fragments of bones first submitted to me in 1840. He alone can adequately appreciate the amount of research involved in such a generalization, as that "there is no bird now known, north of the equator, with which the fossils can be compared;" and when, after a wearying progress through an extensive class, the species is at length found to which the nearest resemblance is made by the fragmentary fossil, and the differences are conscientiously pointed out—as when, *e. g.*, in reference to the humerus of the Albatross, I stated that "it differs therefrom in the more marked angles which bound the three sides,"—the genuine worker and searcher after truth may conceive the feelings with which I find myself misrepresented as having "regarded the specimens as belonging to an extinct species of Albatross." My reference of the bones even to the longipennate tribe of natatorial birds, is stated hypothetically, and with due caution. "On the supposition that this fragment of bone is the shaft of the humerus, its length and comparative straightness would prove it to have belonged to one of the longipennate natatorial birds, equalling in size the Albatross," (loc. cit., p. 411.)

Since the discovery has been made of the manifestly characteristic parts of the genus *Pterodactylus*, in the Burham Chalk-pit, it has been objected that these bones first discovered there, and described by me as resembling those of birds of flight, "are so extremely *thin* as to render it most improbable that they could ever have sustained such an instrument of flight as the powerful wing of the Albatross or of any other bird: their tenuity is in fact such," says the objector, "as to point out their adaptation to support an expanded membrane, but not pinions."* This assertion needs only for its refutation a simple reference to nature; sections of the wing-bones of birds may be seen in the Museum of the Royal College of Surgeons, and have been exposed to view, since the discovery of their structure, by the founder of that Collection, in every Museum of Comparative Anatomy worthy to be so called. To expose the gratuitous character of the objection above cited, I have selected for

* Mantell, 'Wonders of Geology,' 1848, vol. i, p. 441.

illustration in T. XXXII, fig. 1, a section of the very bone that directly sustains the large quill-feathers in the Pelican: its parietes are only half as thin as those of the anti-brachial bone of the great Pterodactyle, figured in T. XXX, fig. 1: they are thinner than those of the humerus figured in T. XXIX, fig. 1.

Hunter, who had obtained some of the long bones, with thin parietes and a wide cavity, from the Stonesfield Slate, has entered them in his MS. Catalogue of Fossils, as the "Bones of Birds:" and perhaps no practical anatomist had had greater experience in the degree of tenuity presented by the compact walls of the large air-cavities of the bones in that class. Of all the modifications of the dermal system for combining extent of surface with lightness of material, the expanded feather has been generally deemed the consummation. Well might the eloquent Paley exclaim:—"Every feather is a mechanical wonder—their disposition, all inclined backwards, the down about the stem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, constitute a vestment for the body, so beautiful and so appropriate to the life which the animal is to lead, as that, I think, we should have had no conception of anything equally perfect, if we had never seen it, or can imagine anything more so." It was reserved for the author of the 'Wonders of Geology,' to prefer the leathern wings of the Bat and Pterodactyle as the lighter form, and to discover that such a structure, as is displayed in T. XXX, fig. 4, was "a most improbable one to have sustained a powerful wing of any bird."

Let me not be supposed, however, to be concerned in excusing my own mistake. I am only reducing the unamiable exaggeration of it. Above all things, in our attempts to gain a prospect of an unknown world by the difficult ascent of the fragmentary-ruins of a former temple of life, we ought to note the successful efforts, as well as the occasional deviations from the right track, with a clear and unprejudiced glance, and record them with a strict regard to truth.

The existence of a species of Albatross, or of any other actual genus of Bird, during the period of the Middle Chalk, would be truly a wonder of Geology; not so the existence of a bird of the longipennate family.

I still think it for the interest of science, in the present limited extent of induction from microscopic evidence, to offer a warning against a too hasty and implicit confidence in the forms and proportions of the purkingean or radiated corpuscles of bone, as demonstrative of such minor groups of a class, as that of the genus *Pterodactylus*. Such a statement as that these cells in *Birds* "have a breadth in proportion to their length of from one to four or five; while in *Reptiles* the length exceeds the breadth of ten or twelve times,"* only betrays the limited experience of the assertor. In the dermal plates of the Tortoise, *e. g.*, the average breadth of the bone-cell to its length is as one to six: and single ones might be selected of greater breadth.

* Mantell, 'Wonders, &c.,' vol. i, p. 441.

With the exception of one restricted family of Ruminants, every Mammal, the blood-discs of which have been submitted to examination, has been found to possess those particles of a circular form: in the *Camelidæ* they are elliptical, as in birds and reptiles. The bone-cells have already shown a greater range of variety in the vertebrate series than the blood-discs. Is it, then, a too scrupulous reticence, to require the evidence of microscopic structure of a bone to be corroborated by other testimony of a plainer kind, before hastening to an absolute determination of its nature, as has been done with regard to the Wealden bone, figured in the 'Geological Transactions," vol. v, pl. xiii, fig. 6?*

As a matter of fact, the existence of Pterodactylian remains in Chalk was not surmised through any observation of the microscopic structure of bones that are liable to be mistaken for those of birds, but by the discovery of the characteristic portions of the Pterodactyle, defined by Mr. Bowerbank, as follows, in his original communication of their discovery to the 'Geological Society of London,' May 14th, 1845.

"I have recently obtained from the Upper Chalk† of Kent, some remains of a large species of *Pterodactylus*. The bones consist of—

1. "The fore part of the head, as far as about the middle of the *cavitas narium*, with a corresponding portion of the under jaws,—many of the teeth remaining in their sockets, (T. XXXI, figs. 1-5.)

2. "A fragment of the bone of the same animal, apparently a part of the coracoid, (T. XXXI, fig. 7.)

3. "A portion of what appears to be one of the bones of the auricular digit, from a Chalk-pit at Halling, (T. XXXI, fig. 8.)

4. "A portion of a similar bone, from the same locality as No. 1, (T. XXXI, fig. 9.)

5. "The head of a long bone, probably the tibia, belonging to the same animal as the head, No. 1, (T. XXXI, fig. 10.)

6. "A more perfect bone of the same description, not from the same animal, but found at Halling," (T. XXXI, fig. 11.)

In a subsequent communication, dated December 1845, Mr. Bowerbank states, with regard to the specimens, Nos. 5 and 6, which he supposed to be parts of a tibia, that "on a more careful comparison with the figures of *Pterodactylus* by Goldfuss, I am inclined to believe they are more likely to be portions of the ulna."

* I would request the reader who may be desirous to exercise an independent judgement on such facts as have been published on this point, to compare, for example, some of the cells figured by Mr. Bowerbank, in Pl. i, fig. 9, of the 'Quarterly Journal of the Geological Society,' vol. iv, as being those of the bone of a bird, with some of the wider cells, fig. 1, of the same plate, as being those of the bone of a Pterodactyle; and contrast the want of a parallelism in the cells of the Wealden bone, fig. 9, with the parallelism of the long axes of the cells in the bone of the Albatross, fig. 3.

† See the Note, ante, p. 80.

With respect to the long bone (T. XXXI, fig. 11), comparing it with that figured in T. XXX, fig. 4, referred by me to *Cimoliornis diomedeus,* Mr. Bowerbank writes:—

"Although the two specimens differ greatly in size, there is so strong a resemblance between them in the form and angularity of the shaft, and in the comparative substance of the bony structure, as to render it exceedingly probable that they belong to the same class of animals;" and he concludes by remarking that "if the part of the head in my possession (see fig. 1), be supposed similar in its proportions to that of *Pterodactylus crassirostris,*—and there appears but little difference in that respect,—it would indicate an animal of comparatively enormous size. The length of the head, from the tip of the nose to the basal extremity of the skull of *P. crassirostris,* is about $4\frac{5}{8}$ inches, while my specimen would be, as nearly as can be estimated, $9\frac{1}{8}$ inches. According to the restoration of the animal by Goldfuss, *P. crassirostris* would measure, as nearly as possible, three feet from tip to tip of the wings, and it is probable that the species now described would measure at least six feet from one extremity of the expanded wings to the other; but if it should hereafter prove, that the bone described and figured by Professor Owen belongs to a Pterodactyle, the probable expansion of the wings would reach to at least eight or nine feet. Under these circumstances, I propose that the species described above shall be designated *Pterodactylus giganteus,*" (p. 8.)

In a subsequent Memoir, read June 9th, 1847, and published in the 'Quarterly Journal of the Geological Society,' February, 1848, Mr. Bowerbank gives figures of the "bone-cells" from the jaw of a *Pterodactyle* (Pl. i, fig. 1), from the shaft of the bone in question (ib., fig. 2), and from the femur of a recent Albatross (ib., fig. 13), in corroboration of the required proof; and he adds:—"Fortunately the two fine specimens from the rich collection of Mrs. Smith, of Tonbridge Wells, represented by fig. 1, Pl. ii, in a great measure justify this conclusion, and in the bone *a*, which is apparently the corresponding bone to the one represented by fig. 1 in Professor Owen's Paper, the head is very nearly in a perfect state of preservation," (Op. cit., p. 5.) Mr. Bowerbank, in his explanation of Pl. ii, describes the two specimens above mentioned, as:—"Fig. 1. Radius and ulna of *Pterodactylus giganteus,* in the Cabinet of Mrs. Smith, of Tunbridge Wells," (Tom. cit., p. 10.) He proceeds to state, "there are two other similar bones imbedded side by side in the Collection of Mr. Charles. of Maidstone, of still greater dimensions than those from the Cabinet of Mrs. Smith," and he assigns his grounds for the conclusion, that "the animal to which such bones belonged could, therefore, have scarcely measured less than fifteen or sixteen feet from tip to tip of its expanded wings." These bones are represented in T. XXIX of the present Monograph.

The Committee of the British Association, for the Reform and Regulation of Zoological Nomenclature, amongst other excellent rules, have determined, that:—

"Names not clearly defined may be changed. Unless a species or group is

intelligibly defined when the name is given, it cannot be recognised by others, and the signification of the name is consequently lost. Two things are necessary before a Zoological term can acquire any authority, viz. *definition* and *publication*. Definition properly implies a distinct exposition of essential characters, and in all cases we conceive this to be indispensable.*

Now with regard to the *Pterodactylus giganteus*, I always understood Mr. Bowerbank to apply the term to the species to which the long wing-bone first described by me might appertain, under the circumstances of its being proved to belong to a Pterodactyle, and my belief in this definition of his species was confirmed by the fact of his subsequently figuring two similar and equal-sized bones in the 'Quarterly Journal of the Geological Society,' Vol. IV, pl. 2, fig. 1, (Proceedings of the Society for June 9th, 1847) as the "radius and ulna of *Pterodactylus giganteus*." So far as a species can be intelligibly defined by figures, that to which the term *giganteus* was, in 1845, provisionally, and in 1847 absolutely applied, seemed to be clearly enough pointed out by the Plate 2, in the Work above cited. But with the large bones appropriately designated by the term *giganteus*, some part of a smaller *Pterodactyle*, including the portions of jaws first announcing the genus in the Chalk, had been associated under the same name. Supposing those bones to have belonged to a young individual of the *Pterodactylus giganteus*, no difficulty or confusion would arise. After instituting, however, a rigid comparison of these specimens, I was compelled to arrive at the conclusion that the parts figured by Mr. Bowerbank, in Plate 2, figs. 1 and 2, of Vol. II of the 'Quarterly Geological Journal,' and the parts figured in Plate 2, figs. 1 *a* and *b* of Vol. IV, of the same Journal, both assigned by Mr. Bowerbank to the *Pterodactylus giganteus*, belonged to two distinct species. The portions of the scapula and coracoid of the Pterodactyle (Pl. 1, fig. 2, tom. cit.) indicates, by its complete anchylosis, that it has not been part of a young individual of the species to which the large antibrachial bones (Pl. 2, fig. 1, *a* and *b*, tom. cit.) belonged, although it might well appertain to the species to which the jaws (Pl. 1, fig. 1,) belonged. Two species of Pterodactyle were plainly indicated, as I have shown in the Work by my lamented friend, Mr. Dixon, 'On the Tertiary and Cretaceous Deposits of Sussex,' 4to, p. 402. The same name could not be retained for both, and it was in obedience to this necessity, and not with any idea of detracting an iota from the merit of Mr. Bowerbank's original announcement of the existence of a Pterodactyle in the Chalk, that I proposed the name of *conirostris* for the smaller species, then for the first time distinctly defined and distinguished from the larger remains, to which the name *giganteus* had also been given by Mr. Bowerbank. I proposed the name, moreover, provisionally, and with submission to the Committee for the Reform of Zoological Nomenclature, according to whose rules I believed myself to have been guided.

* See their 'Report,' Trans. of the British Association for 1842, p. 113.

As, however, I have no personal feeling with regard to mere names, I shall apply to the specimens of the jaws of the Pterodactyles, described in this Monograph, the names by which Mr. Bowerbank first made those parts known to Geologists, and before entering upon their descriptions shall premise a few remarks on the Pterodactyles in general.

The Order *Pterosauria* includes species of flying reptiles, so modified in regard to the structure and proportions of the skull, the disposition of the teeth, and the development of the tail, as to be referable, even according to the partial knowledge we now possess of this once extensive group, to different genera.

M. von Meyer, *e.g.*, primarily divides the Order into:—

A. Diarthri. With a two-jointed wing-finger.
Ex. *Pterodactylus* (*Ornithopterus*) *Lavateri.*
B. Tetrarthri. With a four-jointed wing-finger.
Ex. All the other known species of the Order.

These again are subdivided into:—

1. *Dentirostres.* Jaws armed with teeth to their ends: a bony sclerotic ring: scapula and coracoid not confluent with one another:* a short moveable tail.
Ex. *Pterodactylus* proper.
2. *Subulirostres.* Jaws with their ends produced into an edentulous point, probably sheathed with horn: no bony sclerotic: scapula and coracoid confluent: a long and stiff tail.

Ex. *Pterodactylus* (*Ramphorhynchus*) *Gemmingi.*†

The extremity of the upper jaw of the *Pterodactylus Cuvieri*, Bowerbank, is sufficiently perfect to demonstrate that it had a pair of approximated alveoli close to its termination, and we may, therefore, refer it to the Dentirostral division.

In this division, however, there are species which present such different proportions of the beak, accompanied by differences in the relative extent of the dental series, as would, without doubt, lead to their allocation in distinct genera, were they the living or recent subjects of the modern Erpetologist. In the *Pterodactylus longirostris*, the first species discovered, and made known by Collini in 1784,‡ the jaws are of extreme length and tenuity, and the alveoli of the upper jaw do not extend so

* The condition of the scapular arch in the *P. giganteus*, Bow., *P. conirostris*, Mihi, demonstrates the fallacy of this character.

† Palæontographica, Heft I, 4to, 1846, p. 19.

‡ Acta Academiæ Theodoro-Palatinæ, v, p. 58, Tab. v.

far back as the nostril, T. XXVII, fig. 1. In the *Pterodactylus crassirostris**, (ib. fig. 2,) on the other hand, the jaws are short, thick and obtusely terminated; and the alveoli of the upper jaw reach as far back as the middle of the variety which intervenes between the nostril and the orbit, and which Goldfuss terms the "cavitas intermedia."

In the solid or imperforate part of the upper jaw anterior to the nostril the *Pterodactylus longirostris* has twelve long subequal teeth, followed by a few of smaller size: the same part of the jaw in the *Pter. crassirostris* has but six teeth, of which the first four are close together at the end of the jaw, and the first three shorter than the rest. The "cavitas intermedia" in *P. longirostris* is much smaller than the nostril: in the *P. crassirostris* it is larger than the nostril. Were these two species of dentirostral *Pterosauria* to be taken, as by the modern Erpetologist they assuredly would, to be types of two distinct genera, the name *Pterodactylus* should be retained for the longirostral species, as including the first-discovered specimen and type of the genus; and the crassirostral species should be grouped together under some other generic name.

Pterodactylus Cuvieri, *Bowerbank*. Tab. XXVIII, figs. 1—7.

'Proceedings of the Zoological Society,' January 14th, 1851.

The specimen of gigantic Pterodactyle, exhibited and so named by Mr. Bowerbank at the meeting of the Zoological Society, January 14th, 1851, and which he has confided to me for description in the present Monograph, consists of the solid anterior end, *i. e.*, of the imperforate continuous bony walls, of a jaw, compressed, and decreasing in depth, at first rapidly, then more gradually, to an obtusely pointed extremity. As the symphysis of the lower jaw is long and the original joint obliterated, and its depth somewhat rapidly increased by the development of its lower and back part into a kind of ridge, in some smaller Pterodactyles, the present specimen, so far as these characters go, might be referred to the lower jaw, and its relatively inferior depth to the upper jaw in the *Pter. giganteus*, would seem to lead to that conclusion. But the present is plainly a species which has a relatively longer and more slender snout, and the convex curve formed by the alveolar border, slight as it is, decides it to be part of the upper jaw. The lower jaw, moreover, might be expected by the analogy of the smaller Pterodactyles to be flatter or less acute below the end of the symphysis.

The specimen of *Pterodactylus Cuvieri* consists of the anterior extremity of the upper jaw of seven inches in extent, without any trace of the nasal or any other

* Goldfuss, Beiträge zur Kenntniss Verschiedener Reptilien der Vorwelt, 4to, 1831, sec. i, Tabs. vii, viii, ix.

natural perforation of its upper or lateral parietes, and corresponds with the parts marked *a*, *b*, T. XXVII, figs. 1 and 2. From the number of teeth contained in this part, the *Pter. Cuvieri* presents a much closer resemblance to the *Pter. longirostris*, (ib., fig. 1,) than to the *Pter. crassirostris*, (ib., fig. 2;) and, if the entire skull were restored according to the proportions of the *Pter. longirostris*, it would be twenty-eight inches in length.

But nature seems never to retain the same proportions in species that differ materially in bulk. The great Diprotodon, with the dental and cranial characters of a Kangaroo, does not retain the same length of hinder limbs as its living homologue; the laws of gravity forbid the saltatory mode of locomotion to a Herbivore of the bulk of a Rhinoceros; and accordingly, whilst the hind legs are shortened, the fore limbs are lengthened, and both are made more robust in the Diprotodon than in the Kangaroo. The change of proportions of the limbs of the Sloths is equally striking in those extinct species which were too bulky to climb: *e. g.*, the Megatherium and Mylodon. We may therefore infer, with a high degree of probability, when a longirostral Pterodactyle much surpassed in bulk the species so called "par excellence," that the same proportions were not maintained in the length of the jaws, and that the species to which the fine fragment, (T. XXVIII, fig. 1,) belonged, far as it has exceeded our previous ideas of the bulk of a flying reptile, did not sustain and carry through the air a head of 2 feet 4 inches in length, or double the size of that of the Pelican. We see, in fact, that the size of the teeth was not increased in the ratio of that of the jaws.

Although the fractured hinder part of the jaw shows no trace of the commencement of the wide nasal aperture, there is a plain indication that the jaws were less prolonged than in the *Pt. longirostris*, in the more rapid increase of the depth of the jaw. Opposite the ninth tooth, *e. g.*, the depth of the jaw equals two fifths of the length of the jaw in advance of that tooth, whilst in the *Pt. longirostris* it is only two sevenths. The contour of the upper border of the jaw in the *Pterodactylus Cuvieri* differs from that in both the *Pt. longirostris*, *Pt. crassirostris*, and *Pt. Gemmingi*, in sinking more suddenly opposite the ninth, eighth, and seventh teeth, than along the more advanced part of the jaw—a character which, while it affords a good specific distinction from any of those species, indicates the hinder parts of the head, that are wanting in the present specimens, to have been shorter, but relatively much deeper, than in the *Pt. longirostris*.

The first pair of alveoli (figs. 1 and 4, *a*) almost meet at the anterior extremity of the jaw, (T. XXVIII, fig. 3,) and their outlet is directed obliquely forwards and downwards; the obtuse end of the premaxillary above those alveoli is about two lines across. The palate, (ib., fig. 4,) quickly expands to a width of three lines between the second alveoli, then to a width of four lines between the fourth alveoli; and more gradually, after the ninth alveoli, to a width of six lines between the eleventh alveoli, *a'*: here the palate appears to have been slightly crushed; but in the rest of its extent it

presents its natural form, being traversed longitudinally by a moderate median ridge, on each side of which it is slightly concave transversely. It is perforated by a few small irregular vascular foramina; but the bony roof of the mouth is continued for an extent of six inches without any trace of its interruption by the naso-palatal aperture. There are no orifices on the inner side of the alveoli: the successional teeth, as will be presently shown, emerge as in the Crocodile, from the old sockets, and not as in certain Mammals and Fishes, by foramina distinct from them. The second and third alveoli are the largest; the fourth, fifth, and sixth the smallest, yet they are more than half the size of the foregoing; with which the rest are nearly equal. The outlets of the alveoli are elliptical, and they form prominences at the side of the jaw, or rather the jaw there sinks gently in between the alveoli, and is continued into the bony palate, without any ridge, the vertical wall bending round to form the horizontal plate. The greatest breadth of the under surface of the jaw, taken from the outside of the alveoli, varies only from seven lines across the third pair to nine lines across the eleventh pair of alveoli; and from this narrow base the sides of the jaw converge with a slight convexity outwards at the anterior half of the fragment, but are almost plane at the deeper posterior half, where they seem to have met at an acute superior ridge; indeed, such a ridge is continued to within an inch of the fore part of the jaw, where the upper border becomes more obtuse.

The whole portion of the jaw consists of one uninterrupted bone—the premaxillary; the delicate crust of osseous substance, as thin as paper, is traversed by many irregular cracks and fissures, but there is no recognizable suture marking off the limits of a maxillary or nasal bone. The bone offers to the naked eye a fine fibrous structure, so fine as to produce almost a silken aspect: the fibres or striæ being longitudinal, and impressed at intervals of from two to six lines by small vascular foramina.

The first socket on the right side contains a young tooth which protrudes about a third of an inch obliquely downwards and forwards, (fig. 1, *a*:) the fifth socket on the right side and the eighth on the left contain the germ of a younger tooth, the point of which does not protrude beyond the socket; it lies close to the inner wall of the socket of the old tooth, from which it could have emerged, as in the Crocodile. Two fully developed teeth, (figs. 5 and 6,) are preserved in the same block of chalk with the jaw. One of these is 1 inch 4 lines in length, sabre-shaped, subcompressed, slightly bent, and gradually diminishing in breadth from the widely-open base to the apex: this part is broken off in both specimens, showing the crown to be composed of a compact hard dentine, sheathed by a thin coat of shining enamel: about 9 lines of the basal part of the present tooth, (fig. 5,) is coated by a thin layer of cement. The enamel is marked by extremely fine longitudinal ridges, with an irregular or thready course, of unequal length and with wide intervals, as shown in the magnified view, (fig. 7.) The second, (fig. 6,) is a somewhat smaller tooth; having the same structure.

The unique specimen above described was obtained from the Burham Chalk-pit, Kent, and forms part of the fine Collection of James S. Bowerbank, Esq., F.R.S.

PTERODACTYLUS GIGANTEUS, *Bowerbank.* Tab. XXXI.

PTERODACTYLUS GIGANTEUS. *Bowerbank.* Proceedings of the Geological Society, May 14, 1845; in the 'Quarterly Journal of the Geological Society,' February, 1846.

— CONIROSTRIS. *Owen.* Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 401, T. XXXVIII.

This specimen consists of the upper jaw, as far as the commencement of the nostril, (T. XXXI, fig. 2, *n*,) with the corresponding part of the lower jaw. The upper jaw is a subcompressed, three-sided cone, with a more obtuse apex than in *Pterodactylus Cuvieri,* and more rapidly and regularly increasing in depth as it approaches the nostrils, the sides converging at an acute angle as they ascend from the alveolar border, arching over the apex of the jaw, but meeting within an inch from this part at a ridge, which is rather more obtuse than that in *Pt. Cuvieri,* and formed at a somewhat less acute angle, (figs. 3 and 4.) The surface of the bone appears naturally to have been less even or level than in the larger species, and the thin osseous plate is similarly fissured and cracked. The part appears, however, to have suffered little compression; the palate, where it is exposed at the back part of the jaw, being entire, and presenting a concave longitudinal channel on each side of a prominent median ridge: its breadth opposite the ninth alveolus is 8 lines; the depth of the jaw at that part being 14 lines; the breadth of the base of the jaw, there, outside the alveoli, is 11 lines. The sides of the jaw are plane, but sink in a little between the alveoli, where they become continuous with the palatal surface. The alveolar border of the jaw is slightly convex lengthwise along its anterior third, and is continued straight along the rest of its extent. There are ten pairs of alveoli in the part of the upper jaw anterior to the bony nostril, the alveoli being separated by intervals about equal to their own diameter. In the *Pt. Cuvieri* there are at least twelve pairs of alveoli anterior to the nostril, and there may have been more, as there are in the *Pt. longirostris.* In the *Pt. crassirostris* there are only six pairs of alveoli in the corresponding part of the upper-jaw, and the fourth, fifth, and sixth, are separated by intervals of thrice the diameter of the alveolus.

Such characters as these place in a strong light the specific distinctions of the *Pterodactyli* compared. The species under consideration exemplifies in the Cretaceous epoch the crassirostral group of the older secondary *Pterosauria,* as the gigantic *Pt. compressirostris* does the longirostral group; the *Pt. Cuvieri* approaches nearer a middle term between the two types of the groups in question. The length of the jaw anterior to the nostril in the *Pt. crassirostris,* described by Goldfuss,* is 13 lines,

* Nova Acta Acad. Nat. Cur., tom. xv, pt. i, p. 63.

that of the *Pt. giganteus* is 2 inches 3 lines; the total length of the head of the *Pt. crassirostris* is 4 inches 8 lines, that in the *Pt. giganteus*, restored on the same scale, would be 9 inches, and the proportions on which this calculation is made are much more likely to have been maintained, than those of the *Pt. longirostris*, in reference to the more gigantic *Pt. Cuvieri;* but the teeth are absolutely shorter, and relatively much smaller, than in the *Pt. crassirostris*.

The lower jaw, fig. 5, has an obtuse rounded termination anteriorly like the upper one, fig.4, but is a little narrower there, and is flatter, its under part being less convex than the corresponding exposed part of the upper jaw is above: the median inferior ridge behind this part is more suddenly developed than that upon the upper jaw, and the progressively deepening sides of the lower jaw are bent inwards before they form the ridge, being convex near the alveoli, and becoming concave at the base of the ridge, in the transverse direction: and this modification does not appear to be the result of accidental pressure. The solid or confluent symphysis has an extent of more than 2 inches, but the bone is too much broken away at its back part to determine its precise extent: it is evident, however, that the rami diverging from it were of less vertical extent than the ridged part of the symphysis from which they diverge, and this character is also shown in the lower jaw of the *Pt. longirostris*, and *Pt. Gemmingi*. On the right side of the lower jaw, which is best preserved, there are nine alveoli, and part of a tenth, corresponding in size and spacing with those above. The inner alveolar wall extends so far inwards, horizontally, that if discovered alone, it might well be mistaken for the palatal plate of an upper jaw. It is not united with that of the opposite side to an extent corresponding with the bony palate above; but to what extent the symphysis of the jaw is continued backwards, the specimen does not allow to be precisely determined. This broad inner alveolar plate of the lower jaw is slightly concave transversely, forming a wide longitudinal channel about two lines and a half in breadth along the inner side of the alveolar border: to the extent to which it may be united to the opposite plate, a median longitudinal ridge will be formed dividing the two channels; and presenting a structure closely corresponding with that of the palate above.

The teeth are preserved, in situ, in some of the alveoli, of both the upper and lower jaws. The enamelled crown is a less elongated and narrow cone than in either the *Pt. Cuvieri*, or the *Pt. crassirostris*, and it is less compressed; it does not exceed one line and a half in length. The fang is longer, and after a slight expansion maintains the same diameter, or contracts a little towards its basal termination. The smooth polished coronal enamel shows the same extremely fine raised striæ, with an irregular course and wide intervals, as in the teeth of *Pt. Cuvieri*. The basal cement has a more irregular external surface. The fractured tooth in the sixth alveolus of the left side shows well the form of the transverse section at the base of the crown, and the proportional size of the pulp-cavity. This, as usual, is occupied by a sparkling

siliceous spath. I am not at present aware of any species of Pterodactyle in which the teeth are so short and thick as in the *Pt. giganteus,* (see the magnified view, fig. 6.) Those figured in Pl. 27, Vol. iii., 2d Series, of the 'Geological Transactions,' on the supposition that they might belong to the Pterodactyle, appertain to a species of Fish. The point of a successional tooth projects from the fore part of the ninth socket on the right side of the upper jaw, from which its predecessor has fallen, proving, as in the larger species, that the crowns of the successional teeth do not emerge, as Cuvier surmised to be the case in *Pt. longirostris,** from a distinct orifice on the inner side of the socket of the old tooth, as in the Mammalia.

The substance of the osseous walls of the above-described portions of jaws is as thin and delicate as in the foregoing species: it does not present the same fine longitudinally striated surface as in the *Pt. Cuvieri;* but it is similarly perforated by numerous minute vascular foramina, which are largest and most abundant near the alveolar border at the fore part of the jaw.

The unique specimen above described was discovered in the Burham Chalk-pit, Kent, and is in the Collection of James Scott Bowerbank, Esq., F.R.S.

Scapular Arch and Bones of the Extremities of the Pterodactylus giganteus, *Bowerbank.* Tab. XXXI, figs. 7, 8, 9, 10—13.

Perhaps no part of the skeleton of the Pterodactyle more closely resembles in form that of the bird, than the scapular arch: and in no specimen has this arch been better preserved than in the *Pterodactylus macronyx.*† The scapula is shown in those specimens to be long, sabre-shaped, and to form a moiety of the articular concavity for the head of the humerus, and the coracoid to be stronger, straighter, and shorter than the scapula, and with a subbifid protuberance near the articular surface for the humerus: the opposite end of the coracoid terminates by a rather oblique truncation, but without expanding: both the elements of the arch are anchylosed together, where they meet at rather an acute angle to form the shoulder-joint. In the *Pt. crassirostris*‡ the two bones appear not to have been anchylosed, the more slender and slightly curved bone, 17, in Prof. Goldfuss's plate, is called the coracoid, the stronger and straighter one, 16, the scapula: but this determination seems to have been based upon the crushed specimen, in which there has been sufficient displacement of parts to render it very probable that the scapula and coracoid have suffered some change of position: the fore part of 17, which I believe to be the scapula, shows a tuberosity near the articular end, which forms an angle between that and the shaft of the bone: the coracoid, 16,

* Ossemens Fossiles, tom. v, pt. ii, pp. 364, 367.

† See Dr. Buckland's Memoir, 'Geological Transactions,' 2d Series, vol. iii, pl. xxvii, X, 9; and Von Meyer, in the 'Nova Acta Acad. Nat. Curios.,' tom. xv, pt. ii, Tab. lx, fig. 8.

‡ Goldfuss, *ut supra,* T. VII, 16, 17.

exhibits a stronger tuberosity near the same part; the sternal end of this bone is slightly expanded and rounded. The length of the scapula is rather more than one-third of that of the entire skull.

In the same block of chalk as that which contained the fore part of the jaws of the *Pt. giganteus*, is preserved the confluent extremities of the right scapula and coracoid, one third larger than the corresponding parts in the *Pt. crassirostris*, and one-fourth larger than those in the *Pt. macronyx*. The portion of scapula, (T. XXXI, figs. 7 and 8, 51,) includes thirteen lines of the humeral end of that bone; the fractured part of the body showing that part to be subcompressed, with the side next the ribs slightly concave, the opposite side convex; the long diameter of this section of the bone is 3 lines; its short diameter 1 line; it expands as it approaches the shoulder joint, and developes an obtuse oval tubercle, *a*, from its upper and inner border about 4 lines from the articular end; a low acromial ridge is extended from the outer side of the bone, from near the origin of the tubercle, to the outer and fore part of the glenoid cavity: the inner and posterior border is expanded into a third ridge which joins a corresponding one from the same part of the coracoid. Of this bone, 52, about ten lines is preserved: the transverse section exposed at the fractured end is oval, and measures $3\frac{1}{2}$ lines by 2 lines; the expansion of the bone to form the shoulder-joint is rapid. Besides the ridge sent off from the inner and back part to join the one above mentioned from the scapula, there is a much stronger process, *c*, developed from the under and fore part of the coracoid, as in that of the *Pt. macronyx,* between which and the glenoid surface the bone is perforated by a narrow canal, the inner outlet of which is just above the inner ridge. If we carry forwards the two straight lines respectively parallel with the outer borders of the scapula and coracoid, they will meet at an angle somewhat less acute than those in the *Pt. macronyx*. By a trace of the original suture we may see that the coracoid has formed about two thirds of the glenoid cavity, (fig. 7, *g*:) the long diameter of that cavity measures 6 lines, its short diameter $3\frac{1}{2}$ lines; in the direction of which it is flat above and slightly convex below; being concave only in the direction of its long axis; its contour is reniform, the convex border being extended upon the acromial ridge. The long diameter of the glenoid cavity in the *Pt. macronyx* measures 4 lines; and the absence of the tuberosity on the scapula makes that end of the bone relatively more feeble than in the present instance. As the parts are fully one third larger than those in the *Pt. crassirostris,* we may estimate the skull of the present species according to the proportions of the scapula to the skull in *Pt. crassirostris,* as having been about 7 inches in length. Both the scapula and coracoid are hollow, the cavity being surrounded by a very thin compact wall, and being subdivided by a few much thinner plates.

There is a fragment of a bone, (T. XXXI, fig. 9,) in the same block of chalk, which, from its rapid expansion, I am induced to suspect to be part of the sternum: its thickest part presents a coarse cancellous structure: from this part it expands into a thin plate, of which, however, not enough remains to indicate its original form.

Several portions of long bones figured in T. XXXI, may well belong, by their size, to the same species as the portion of jaws, figs. 1 and 2, in the same plate: two of them, figs. 11 and 12, are from a different locality, Halling pit, but from the same formation—the Middle Chalk of Kent. As all these fragments, however, consist only of the simple hollow shaft, I shall proceed with the description of the better preserved specimens from the chalk which are referable to the genus *Pterodactylus.*

PTERODACTYLUS COMPRESSIROSTRIS, *Owen.* Tab. XXVII, figs. 8, 9, and 10.

This species is represented by two portions of the upper jaw, obtained from the Middle Chalk of Kent, the hinder and larger of which includes the beginning of the external nostril, (fig. 8, *n.*) The depth of the jaw at this part is 14 lines, whence it gradually decreases, so as, at a distance of 3 inches in advance of this, to present a depth of 10 lines, indicating a jaw as long and slender as in the *Pterodactylus longirostris*, supposing the same degree of convergence of the straight outlines of the upper and alveolar borders of the jaw to have been preserved to its anterior end: that this was actually the case is rendered most probable by the proportions of the smaller anterior part of the jaw, (T. XXVIII, fig. 8′ and 9′,) obtained from the same pit, if not from the same block of Chalk, and which, with a vertical depth of 7 lines at its hinder part, decreases to one of 6 lines in an extent of $1\frac{1}{2}$ inch in advance of that part. The sides of the jaw as they rise from the alveolar border incline a little outwards before they converge to meet at the upper border. This gives a very narrow ovoid section at the fore part of the larger fragment (fig. 9*), the greatest diameter, at its lower half, being 4 lines, and the sides meeting above at a slightly obtuse ridge. This very gradually widens as the jaw recedes backwards, where the entireness of the walls of the smoothly convex upper part of the jaw proves that the narrowness of that part is not due to accidental crushing. Had that been the case, the thin parietes arching above from one side to the other would have been cracked. The only evidence of the compression to which the deep sides of the jaw have been subject is seen in the bending in of the wall above the alveoli, close to the upper ridge, at the fore part of the fragment, in the crushed state of the palate at that part, and in a slight depression of the left side of the jaw anterior to the nostril.

In an extent of alveolar border of $3\frac{1}{2}$ inches, there are eleven sockets, the anterior one on the right side retaining the fractured base of a tooth: the alveoli are separated by intervals of about one and a half times their own diameter; their outlets are elliptical, and indicate the compressed form of the teeth: they are about 2 lines in long diameter, at the fore part of this fragment, but diminish as they are placed more backwards, the last two being developed beneath the external nostril.

The bony palate is extremely narrow, and presents, in the larger portion, fig. 10, a median smooth convex rising between two longitudinal channels, which are bounded externally by the inner wall of the alveolar border. There is no trace of a median suture in the longitudinal convexity. The breadth of the palate at the back part of the fragment is 8 lines, at the fore part it has gradually contracted to less than 3 lines, but it is somewhat crushed here, (fig. 10, *a*.) The naso-palatine aperture commences about half a line in advance of the external nostril, 3 inches behind the fore part of the larger portion of the skull: its form and extent, so far as it is preserved, are accurately shown in fig. 10, *p*, and it well exemplifies, in this specimen, the characteristic extent of the imperforate bony palate formed by the long single premaxillary bone in the present order of Saurians.

The fragment from the more advanced part of the jaw, fig. 8, contains five pairs of alveoli, in an extent of 2 inches, these alveoli being rather larger and closer together than in the hinder part of the jaw. Owing to the compression which the present portion has undergone, the orifices of the alveoli are turned outwards; the bony palate being pressed down between the two rows, and showing, probably as the result of that pressure, a median groove between two longitudinal convex ridges; but the bone is entire and imperforate. The form of the upper jaw in the present remarkable species differs widely from that of the two previously described specimens from the Chalk, in its much greater elongation, its greater narrowness, and from the *Pt. Cuvieri,* more especially, in the straight course of the upper border of the jaw, as it gradually converges towards the straight lower border in advancing to the anterior end of the jaw. The alveoli, and consequently the teeth, are relatively smaller in proportion to the depth of the jaw than in the *Pt. Cuvieri,* and are more numerous than in the *Pt. giganteus:* they are, probably, also, more numerous than in the *Pt. Cuvieri;* although, as the whole extent of the jaw anterior to the nostril is not yet known in that species, it would be premature to express a decided opinion on that point. As we may reasonably calculate from the fragments preserved, (T. XXVII, figs. 7 and 8,) that the jaw of the *Pterodactylus compressirostris* extended seven inches in front of the nostril, it could not have contained less than twenty pairs of alveoli, according to the number and arrangement of those in the two portions preserved.

The osseous walls in both portions present the characteristic compactness and extreme thinness of the genus: the fine longitudinal striæ of the outer surface are more continuous than in the *Pt. Cuvieri,* in which they seem to be produced by a succession of fine vascular orifices produced into grooves. The conspicuous vascular orifices are almost all confined to the vicinity of the alveoli in the *Pt. compressirostris.* This species belongs more decidedly than the *Pt. Cuvieri* to the longirostral section of the *Pterosauria:* whether it had an edentulous prolongation of the fore part of the upper and lower jaw, as in the *Pt. Gemmingi,* remains to be proved.

In attempting to form a conception of the total length of the head of the very remarkable species of Pterodactyle, represented by the portions of jaw above described, we should be more justified by their form in adopting the proportions of that of the *Pt. longirostris* than in the case of the *Pt. Cuvieri:* but, allowing that the external nostril may have been of somewhat less extent than in the *Pt. longirostris,* we may still assign a length of from 14 to 16 inches to the skull of the Pterodactyle in question, of which I have attempted an analogical restoration in T. XXVII.

It could not have been anticipated that the first three portions of Pterodactylian skull, and almost the only portions that have yet been discovered in the Cretaceous Formations, should have presented such well-marked distinctive characters one from the other as are described and illustrated in the present Monograph. Such, nevertheless, are the facts; and however improbable it may appear, on the doctrine of chances, to those not conversant with the fixed relations of osteological and dental characters, that the three corresponding parts of three Pterodactyles, for the first time discovered, should be appropriated to three distinct species, I have no other alternative, in obedience to the indications of Nature, than to adopt such determination.

The portions of the skull of the *Pterodactylus compressirostris,* like those of the *Pt. Cuvieri* and *Pt. giganteus,* were discovered in the Chalk-pit at Burham, Kent, and are in the Collection of James Scott Bowerbank, Esq., F.R.S., to whose skill is due the exposure of the palatal surface and the left side of the portion of the jaw, figured in T. XXVIII, figs. 8 and 10.

Long Bones of Pterodactylus Cuvieri. Tab. XXX, figs. 1, 2, and 3.

The bone which, from its size, and from the character of its external surface may be, with most probability, referred to the largest of the above-defined species of Cretaceous Pterodactyles, is that which forms the subject of figures 1, 2, and 3, T. XXX. It was discovered in the Chalk-pit, at Burham, Kent, and is now in the Collection of J. Toulmin Smith, Esq., of Highgate.

The length of the bone in proportion to its thickness is too great to be compatible with its being the humerus; and indicates it to be either one of the antibrachial bones; or, more probably, from its similarity in shape to the long bones of most frequent occurrence in smaller species, the first or the second phalanx of the elongated wing-finger.

One end of the bone is nearly entire, the other end is wanting, the total length of the specimen being 14½ inches. The longest diameter of the preserved extremity is 2 inches 3 lines, whence the shaft decreases to a diameter, in the same direction, of 1 inch, and then more gradually expands to a diameter of 1 inch 3 lines at the fractured end. The shaft soon assumes a triedral figure, with the angles rounded off, and the breadth of the narrowest side is shown in fig. 3. The contour of the best

preserved end is shown at fig. 2*, where *a* and *b* may give the form and position of natural articular surfaces, but there seems to have been some slight restoration here: *c* is a vacuity where the bone is deficient: the contour of the border of the bone at *a*, fig. 2, which is obviously entire, satisfactorily indicates, however, the concavity of the articular surface as shown at *a*. This, were the bone an ulna or a phalanx of the wing-finger, would determine the end to be a proximal one: but if the bone were a radius, the concavities *a* and *b* might be adapted to some of the small carpal bones. The presence of a pneumatic foramen, at *p*, figs. 1 and 3, would seem, however, to show the extremity near which it is situated to be a proximal one, and if any trust could be placed in the analogy of the bones of birds, the position of this pneumatic foramen, with the double articular concavity, *a* and *b*, and the three-sided shape of the shaft, would concur in leading to a reference of the bone to the ulna.

The side of the expanded proximal end shown in fig. 2 is slightly convex: that shown in fig. 1 is almost flat, whilst the pneumatic foramen is situated in a deep and narrow concavity or groove which forms the beginning, or the end, of the narrowest of the three sides of the shaft of the bone. But the concavity is speedily changed, as it passes down the shaft, for a convexity, which subsides to a flattened surface at the middle of the shaft, as shown in fig. 2. The broadest side, shown in fig. 2, becomes flattened in the shaft of the bone: the transverse section of which, four inches from the entire end, is shown in fig. 3*, which also gives the thickness of the compact osseous walls of the large air-cavity of the shaft; the thickness of these walls is also shown at their fractured borders in figs. 1, 2, and 3; it exceeds, as might be expected, that of the similarly sized pneumatic wing-bones of the gigantic Crane and Pelican. The character of the surface of the bone closely resembles that of the portion of the jaw of the *Pterodactylus Cuvieri.*

Long Bones of Pterodactylus compressirostris. Tabs. XXIV, XXX, figs. 4 and 5.

In the reference of the long bones from the same locality or division of the Chalk Formations as those from which the jaw-bones of the Pterodactyles have been derived, the chief guide, at present, is the relative size of the parts.

It is not likely that one can err in associating the largest specimens of the wing-bones, such as that above described, to the Pterodactyle, with the largest and strongest jaw, especially when we find the same fine furrows and foramina giving a silky appearance to the surface of both.

The smaller specimens appear by their more compact and smooth surface to belong to the smaller species; but they may have been parts of smaller or younger individuals of the larger species; this, however, is the least likely of the conjectures to which, in the

detached and fragmentary condition in which the part of the skeletons of these huge winged reptiles have reached us, we are reduced in the attempts at their restoration.

In a mass of white chalk, about thirteen inches in length, in the collection of Thomas Charles, Esq., are imbedded three portions of long-bones; one of these (T. XXIV, fig. 1,) is seven inches in length, and shows a crushed articular extremity, 2 inches 2 lines in diameter, the shaft at the opposite fractured extremity being 1 inch 3 lines in the longest diameter; a second fragment (T. XXIV, fig. 3,) is $6\frac{1}{2}$ inches in length, with a diameter of 8 lines at its smaller fractured end, and a diameter of 1 inch 3 lines at its larger fractured end, to which it gradually expands; the third portion (fig. 1, *a a*,) may be a part of the same bone, as fig. 3; it extends from close to the smaller fractured end of that bone in the opposite direction, but in the same line, gradually expanding; its length being 5 inches, and its diameter at the broader fractured end about one inch.

The largest portion of bone (T. XXIV, fig. 1,) presents at its expanded end two surfaces, divided by a strong ridge, about one inch in length, the prominent summit of which has been broken away. One of the surfaces is three times the breadth of the other and is slightly concave transversely, becoming flat as it recedes from the ridge to the tuberosity which terminates the end of the bone furthest from the ridge. This tuberosity is subcompressed; many linear impressions, indicative of the insertion of an aponeurosis or ligament, radiate from it upon the flat surface of the bone: a slight concavity on the end of the bone bounds the tuberosity opposite to the ridge; the rest of that end, including the articular surface, is, as usual, destroyed. The second surface is flat, and slopes away at an open angle from the broader one. Below these surfaces, the outer layer of the thin, compact, osseous wall, has scaled off, and the shaft has been fractured across obliquely, about three inches from the expanded end. The thin wall of the shaft is then continued in broken portions for about three inches lower down, and the rest of the shaft is represented by the cast of its interior in the white chalk. This cast shows, on the surface which was next the bone, several impressions, chiefly in an oblique direction, and nearly parallel with one another; they are shallow and smoothly rounded at the bottom, and may be presumed to have been left by ridges on the inner surface of the medullary or pneumatic cavity of the bone: blood-vessels merely would have perished before the chalk, which must have been introduced into the cavities of these bones in a soft state, could have hardened sufficiently to retain the impression.

With regard to the two other fragments, which are probably parts of an antibrachial bone of the same wing, there is even less character to be obtained from an articular end than in the preceding fragment. On the supposition that the two portions belong to the same bone, it must have been upwards of fourteen inches in length. In the portion, T. XXIV, fig. 3, a part of the inner surface of the thin compact wall of the medullary cavity of the bone is exposed: its smoothness is broken by feeble linear elevations, which are reticularly disposed: it is in appearance very

similar to what may be seen on the smooth inner surface of an air-bone in a large flying-bird, the Pelican or Adjutant Crane, for example: but it is not peculiar to bird's bones. I find, for example, something of the same character on the smooth inner surface of the medullary cavity of the tibia of a young gavial; and on the same inner surface in a femur of a lion; only here there are minute vascular perforations leading to the thick parietes of the bone, which do not exist in the bird's bone, or in the fossil in question. The enlarged end of the portion of bone, T. XXIV, fig. 3, shows evidence of a light open cancellous structure.

The thickness of the compact wall of the large medullary cavity does not exceed half a line, as is shown in fig. 3; it is a little thicker towards the smaller end of the large bone, figure 1. In neither case does it exceed the thickness of the shaft of the humerus or ulna of the Pelican.

The transverse section of the smaller end of the portion of the largest bone, T. XXIV, fig. 1, is a moderately long ellipse, rather more pointed at one end than at the other, indicating an approach to something like a ridge or angle along the corresponding side of the bone. The transverse section of the slender part of the smaller fragments also gives a long ellipse. Neither of the bones show the three-sided figure which characterises the long bone ascribed to the *Pterodactylus Cuvieri*, T. XXX, figs. 1—3, or that, fig. 4 of the same plate, originally figured in the 'Geological Transactions,' 2d series, vol. vi, Pl. 39, fig. 1.

The bone with which the larger portion, fig. 1, T. XXIV, is best comparable, is the humerus, of which it may be the distal portion; but much is wanted in order to attain to a satisfactory determination of it.

On the supposition that it is part of the humerus, and that the other two portions on the same block of chalk are parts of one bone, this bone may be the shaft of the radius.

T. XXX, fig. 5, represents, of the natural size, in the same block of chalk, portions of two longitudinally juxtaposed bones, of nearly equal size, and of similar form, and in this respect, resembling the radius and ulna of the Pterodactyle, as they are shown in the *Pt. longirostris* of Collini and Cuvier,* the *Pt. medius* of Count Munster,† and the *Pt. crassirostris* of Goldfuss.‡ Of one of these bones an extent of upwards of nine inches is preserved in three successive portions. About four inches of the other bone is preserved. Both this and the chief part of the adjoining bone gradually expand to the natural articular end, of which, however, only a small part is preserved in each, showing a shallow smooth concavity; this which is best preserved in the bone, fig. 5*, *d*, obliquely overlaps a small part of the longer bone. The long diameter of the extremity of the shorter portion of bone is one inch five lines; from which the shaft

* Annales du Museum, t. xiii, pl. 31. † Nova Acta Acad. Nat. Curios., vol. xv, pt. i, T. VI.
‡ Ib., T. VII and VIII, 22, 23.

gradually decreases to a diameter of nine lines. The side imbedded in the chalk is convex; that exposed to view is nearly flat; but it is somewhat crushed; the longer portion of the other bone is also too much crushed to give an idea of its natural shape. Like the portions of bone in T. XXIV, these also present a thin wall of compact bone encompassing a very wide medullary or pneumatic cavity; the thickness of the wall equals that of the same part of the ulna of the Pelican, T. XXXII, fig 1.

In the long bone, fig. 4, T. XXX, the original of the fig. 1, Pl. 39, of the 'Geological Transactions,' 2d series, vol. vi, the natural shape of the bone is better preserved; but, unfortunately, only one small portion of the articular surface is preserved at the expanded end, and this merely exhibits part of a shallow concavity, with a thin well-defined border, fig. 4*, *a*. From this articular end to the opposite fractured end of the shaft, the bone measures twelve inches. The breadth of the expanded end is one inch and a half, whence the shaft gradually diminishes to a diameter of nine lines at its middle part, and more gradually increases to a diameter of eleven lines at the broken end.

The bone is very slightly bent lengthwise at its expanded end; it is straight in the rest of its extent; its shaft is unequally three-sided, with the sides smooth and flat, and the angles rounded off. The compact osseous wall is about the third of a line in thickness, and incloses, as in the other specimens, an uninterrupted wide cavity. One of the sides of the bone equals the extreme breadth of the shaft; a second measures seven lines across, the third five lines; the second side increases in breadth, at the expanded end, in a much greater degree than the third or narrowest side; and this seems to have been indented by a natural fossa, and to have been perforated, at *p*, for the admission of air to the cavity, before terminating at the border of the articular concavity. The true nature of this perforation, which I formerly apprehended might be accidental in the fractured state of that end of the bone, and before the discovery of other specimens, is illustrated by the presence of a similar perforation in the larger sized corresponding bone fig. 1, *p*; and gives additional evidence of the remarkable fact of the agreement of the flying-reptiles with birds in the extension of the air-cells into the cavities of the bones.

Tab. XXIV, fig. 2, is the terminal portion of a long bone, with the articular end again unfortunately destroyed, so as to deprive us of one of the best guides to the determination of the fragment. So much of it as is preserved corresponds pretty closely with the proximal end of the foregoing bone: it is subtriedral, with the angles rounded off; the broadest side is imbedded in the chalk; the expansion of the exposed surface is chiefly due to that of the next broadest side; and the narrowest side, as it approaches the articular end, is impressed by a deep and narrow fossa, in which there is an interruption of the thin walls of the bone in the corresponding position of that, which, in the foregoing specimens, I have called a "foramen pneumaticum." A portion of the bone indicates the extension of a process beyond the articular cavity, which

is a character of the proximal end of the first phalanx of the wing-finger, but no part of the articular surface has been preserved.

A similar portion of the corresponding bone of the opposite wing is figured in T. XXXII, fig. 2, and the more frequent occurrence of long bones with the subtriedral shaft, showing a contraction and deepening of the narrowest of the three sides towards one of the expanded ends of the bone, and the presence of the pneumatic foramen in the groove so formed, would indicate them to be one of those bones that are present in greatest number in the framework of the wing of the Pterodactyle, viz., a phalanx of the singularly long and strong wing-finger.

The fragment of the shaft of a bone, with a wide cavity, T. XXXII, fig. 3, shows a different shape from most of the long bones above described ; its transverse section is given at fig. 3′; and from its shape, and the presence of a longitudinal ridge at one side of the flatter and probably posterior part of the shaft, I am inclined to regard it as having been part of a femur ; it bears the same proportion to the diameter of the humerus, T. XXIV, fig. 1, as the femur of the *Pterodactylus crassirostris* does to the humerus, in the beautiful plates of the Memoir by Goldfuss, above quoted.

The fragments of long bones, with the best preserved articular extremity, are those represented of the natural size in T. XXXII, figs. 4 and 5, the former of which was originally figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39, fig. 2, the latter in the 'Quarterly Journal of the Geological Society,' vol. iv, pl. ii, fig. 4.

Both these bones offer the closest resemblance to the trochlear modification of the lower end of the tibia in the bird ; and, if we might presume on that analogy, it would be to the same bone in the gigantic Pterodactyle, that we should, also, refer them, with the present indubitable evidence of the existence of volant reptiles of such dimensions in the formation and localities whence the specimens in question have been derived. But it is not likely that a reptile with distinct tarsal bones would have the same modification of the distal end of the tibia as in the bird.

That which is the subject of fig. 5, in T. XXXII, was obtained by J. Toulmin Smith, Esq. from a chalk-pit near Maidstone, and has not suffered the degree of compression which distorts the specimen, fig. 4, T. XXXII, which was obtained by the Earl of Enniskillen from the same pit. The obliquity of the two parallel, convex, narrow condyles, which I suspected might be the effect of crushing in fig. 4, is shown to be natural in fig. 5 ; the back part of each condyle is broken away, but their antero-posterior extent is fortunately shown in fig. 4. The shaft is naturally compressed from before backwards, as is shown by the section, fig. 5″, and by the side view fig. 5′. There are two depressions and two rough elevations on the surface of the bone, fig. 5, and between the latter a groove extends longitudinally, as if for the passage of a strong tendon ; the vacuity in the thin parietes of the bone above the condyle is, I am assured by Mr. Smith, a natural one, which he himself exposed upon carefully removing the chalk ; and it closely resembles the character of the "foramen pneumaticum" in a

bird's bone, but I am not aware of any in that class which is situated on the back part of the distal end of the tibia. On the opposite side of the bone it presents a concavity, which, however, is deepened by the yielding of the thin parietes of the bone at that part.

In the crushed specimen, fig. 4, the convex contour of the condyles bounding the deep trochlea, describes three fourths of a circle, and hitherto not any of the few well-preserved articular ends of the bones of the Pterodactyles have exhibited this structure.

This remarkable trochlear joint may terminate either the femur, or the short and thick metacarpal bone of the wing-finger.

Figures 6 and 7, T. XXXII, exhibit two portions of a long bone of a gigantic Pterodactyle from the Green-sand near Cambridge, the shaft of which repeats the same inequilateral triedral form as that of figs. 1 and 4, in T. XXX. The smaller fragment of Pterodactylian bone, also from the Green-sand of Cambridge, fig. 8, T. XXXII, indicates, by the strong and broad ridge, that it formed part of the proximal end of a humerus; either of a younger individual, or of a species not larger than that called *Pterodactylus giganteus,* by Mr. Bowerbank, and of which some of the long bones are figured in T. XXXI.

The natural length of the different segments of the wing of the great Pterodactyles of the Chalk may be estimated, according to their proportions in better preserved specimens of the genus, if we can gain approximatively that of any one of the bones, and more especially of the humerus. This I have endeavoured to do, with the following results.

In the *Pterodactylus macronyx, Pt. crassirostris, Pt. longirostris,* the breadth of the distal end of the humerus equals rather more than one fifth of its length, and according to this proportion, the humerus, assigned to *Pt. compressirostris,* Tab. XXIV, fig. 1, may be restored, and would give a total length of ten inches and a half.

In the *Pt. macronyx,* the length of the humerus is equal to three fourths of that of the ulna; in *Pt. crassirostris* it nearly equals one half; in the *Pt. longirostris* it equals two thirds of the ulna; in *Pt. longicaudatus* it equals three fifths of the ulna. Taking the mean of these proportions, which is nearly that in the *Pt. longirostris,* we may assign fifteen inches as the probable length of the antibrachial bones of the *Pt. compressirostris.* If the bone, T. XXX, fig. 1, be the ulna of the *Pt. Cuvieri,* it must have been longer by some inches.

The species of smaller Pterodactyles above cited show a greater difference in the proportions of the metacarpal bone of the wing-finger. In the *Pt. macronyx* this bone is one half the length of the humerus: in the *Pt. longirostris* it is at least of equal length with the humerus; the *Pt. crassirostris* and *Pt. longicaudatus* come nearer the *Pt. macronyx* in the proportions of this bone: we may therefore assign, without hazarding an exaggeration, the length of six inches to both carpus and metacarpus of the *Pt. compressirostris.*

With regard to the first phalanx of the wing-finger, this bone in *Pt. macronyx* is to the humerus as 31 to 26; in the *Pt. crassirostris* it is as 22 to 16; in the *Pt. longirostris* as 17 to 10; in *Pt. longicaudatus* as 2 to 1. In two of the above-cited species it is longer than the ulna, in the other two it is shorter: we shall probably not greatly err if we adopt the mean, and assign an equal length to the first phalanx with the ulna itself in the *Pt. compressirostris*, viz. fifteen inches. In the *Pt. macronyx* the second phalanx of the wing-finger a little exceeds the length of the first: in the other species cited, it is a little shorter; we may assign, therefore, a length of 14 inches to the second phalanx in the *Pt. compressirostris*. Supposing the long bone of the *Pt. Cuvieri* (T. XXX, fig. 1) to be a phalanx of the wing-finger, it equals the dimensions above assigned to those of the *Pt. compressirostris* in its present mutilated state.

With regard to the proportions of the third phalanx, the *Pt. macronyx* offers a marked difference from the three other species here compared: its length being to that of the first phalanx as 5 to 4, whilst it presents the reverse proportions in the rest. So likewise, with regard to the last slender pointed phalanx of the wing-finger, this exceeds the length of the penultimate phalanx in *Pt. longicaudatus*, but falls short of that length in *Pt. longirostris*, the difference being very small in both cases: the last phalanx is not preserved in the specimen of the *Pt. macronyx*,* nor in that from which Professor Goldfuss has conjecturally restored the *Pt. crassirostris*.†

If we assume the penultimate and last phalanges of the *Pt. compressirostris* to have been of equal length, and restore them according to the proportions of those of the *Pt. longirostris*, we may assign the length of 26 inches to the two bones; but if the proportions of the *Pt. macronyx* were preserved in the gigantic species, the last two phalanges would be 30 inches in length. According to the former restoration the length of the bones of one wing, in a straight line, would be 7 feet 2 inches; according to the latter restoration, 7 feet 6 inches. We may be assured that we are within the bounds of moderation, in assigning an expanse of 7 feet to each wing of the smaller of the two great Pterodactyles of the Chalk, and supposing it to have had a breadth of chest from one humeral joint to the other of 1 foot, it would measure 15 feet from the tip of one wing to that of the other, an expanse of pinions rarely equalled, and still more rarely exceeded by the largest Albatross.‡ The *Pterodactylus Cuvieri* was probably upborne on an expanse of wing not less than eighteen feet from tip to tip.

* Geol. Trans., 2d Series, vol. iii, pl. xxvii. † Nova Acta Acad. Nat. Curios., tom. xv, pt. i, Tab. IX.

‡ Latham cites the following testimonies to the extent of the wings of the Albatross:—"Above ten feet, (Foster's Voyage, i, p. 87.) Ten feet two inches, called an enormous size, (Hawkesworth's Cook'. Voy., iii, p. 627.) Eleven feet seven inches, (Parkinson's Voyage, p. 82.) Twelve feet, MS., at Sir Joseph Banks's. One in the Leverian Museum expanded thirteen feet; and Ives mentions one, shot off the Cape of Good Hope, measuring seventeen feet and a half from wing to wing, (See Voyage, p. 5.)" (Latham's History of Birds, vol. x, p. 48, ed., 1824.)

ORDER—*DINOSAURIA.*

Genus, IGUANODON.

Mr. W. H. BENSTED, of Maidstone, the proprietor of a stone-quarry of the Shanklin-sand formation, in the close vicinity of that town, had his attention one day, in May 1834, called by his workmen to what they supposed to be petrified wood in some pieces of stone which they had been blasting. He perceived that what they supposed to be wood was fossil bone, and with a zeal and care which have always characterised this estimable man in his endeavours to secure for science any evidence of fossil remains in his quarry, he immediately resorted to the spot. He found that the bore or blast by which these remains were brought to light, had been inserted into the centre of the specimen (which is figured in T. XXXIII), so that the mass of stone containing it had been shattered into many pieces, some of which were blown into the adjoining fields. All these pieces he had carefully collected, and proceeding with equal ardour and success to the removal of the matrix from the fossils, he succeeded after a month's labour in exposing them to view, and in fitting the fragments to their proper places.*

The quarry in which these remains were brought to light consists of many strata, regularly alternating, of compact lime-stone, and of sand more or less loose. Each stratum is of the thickness of from eight inches to twelve or fourteen inches, and the alternation of the two beds is remarkably regular and equal. The bed in which the fossil turtle *Protemys serrata,* described at pp. 15—19 of the present Monograph was discovered, lies about fifteen feet below the Iguanodon bed, and is remarkable for the accumulations of the spiculæ of sponges, with which it abounds. Not far below this is the "Atherfield clay," which joins the "Wealden," the junction of the two being scarcely discoverable, owing to the similarity in texture and colour of the two clays.

* In a contemporary notice of this discovery, written with evident knowledge of the facts, and within a month after they occurred, it is stated:—"By the great care bestowed upon them, however, by the very intelligent proprietor of the quarry, Mr. W. H. Bensted, nearly all the detached pieces have been collected, and the various bones carefully cleared from the rock which forms their matrix." (Philosophical Magazine, July, 1834.)

Dr. Mantell, referring, in 1848, to this specimen in his 'Wonders of Geology,' vol. i, p. 427, states:—"The rock was shattered to fragments by the explosion, and the bones were broken into a thousand pieces: but after much labour, I succeeded in uniting the several blocks of stone, and ultimately cleared and repaired the bones, and restored the specimen to its present state." As the specimen was presented to Dr. Mantell, from whom it was purchased, with the rest of his Collection, by the British Museum, we are doubtless indebted to his skill as well to that of its discoverer for the actual condition in which it may now be studied.

Amongst the portions of the skeleton recovered by Mr. Bensted, were fortunately a portion of one tooth and the cast of a second in the matrix. These were recognised by him as being the teeth of the Iguanodon, which had previously been discovered in the Wealden of Tilgate Forest,* and which had been described by Dr. Mantell in a Paper printed in the 'Philosophical Transactions' for 1825; where that assiduous explorer of the Wealden acknowledges the mode by which he obtained the required information respecting them.

"As these teeth were distinct from any that had previously come under my notice, I felt anxious to submit them to the examination of persons whose knowledge and means of observation were more extensive than my own. I therefore transmitted specimens to some of the most eminent naturalists in this country and on the continent. But although my communications were acknowledged with that candour and liberality which constantly characterise the intercourse of scientific men, yet no light was thrown upon the subject, except by the illustrious Baron Cuvier, whose opinions will best appear by the following extract from the correspondence with which he honoured me:—

"'Ces dents me sont certainement inconnues; elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la couche mince d'émail qui les revêt, à l'ordre des reptiles. A l'apparance extérieure on pourrait aussi les prendre pour des dents de poissons analogues aux tetrodons, ou aux diodons: mais leur structure intérieure est forte différente de celles-là. N'aurions-nous pas ici un animal nouveau! un reptile herbivore? et de même qu'actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étaient les seuls animaux terrestres, les plus grands d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possédez appartiendrait à cet animal unique, jusqu'à present, dans son genre. Le temps *con*firmera ou *in*firmera cette idée, puisqu'il est impossible qu'on ne trouve pas un jour une partie de la squelette réunie à des portions de mâchoires portant des dents. C'est ce dernier objet surtout qu'il s'agit de rechercher avec le plus de persévérance.'

"These remarks," Dr. Mantell proceeds to say, "induced me to pursue my investigations with increased assiduity, but hitherto they have not been attended with the desired success, no connected portion of the skeleton having been discovered. Among the specimens lately connected, some, however, were so perfect, that I resolved to avail myself of the obliging offer of Mr. Clift (to whose kindness and liberality I hold myself particularly indebted), to assist me in comparing the fossil teeth with those of the recent Lacertæ in the Museum of the Royal College of Surgeons. The result of this examination proved highly satisfactory, for in an Iguana which Mr. Stutchbury

* "The first specimens of the teeth were found by Mrs. Mantell in the coarse conglomerate of the Forest, in the spring of 1822." (Mantell, 'Geology of the South-East of England,' 8vo, 1833, p. 268.)

had prepared to present to the College, we discovered teeth possessing the form and structure of the fossil specimens." (Phil. Trans., 1825, p. 180.) And he afterwards adds :—"the name Iguanodon, derived from the form of the teeth, (and which I have adopted at the suggestion of the Rev. W. Conybeare,) will not, it is presumed, be deemed objectionable." (Ib., p. 184.)

The fortunate discovery by Mr. Bensted was one of those which Baron Cuvier's prophetic glance saw hidden in the womb of time, and the birth of which has served to verify his sagacious conjecture, that some of the great bones collected by Dr. Mantell from the Wealden of Sussex, belonged to the same animal, unique in its genus, as the teeth; and also to confirm the accuracy of their discoverer's determination of the clavicle, femur, and tibia, figured and described by him in the 'Geology of the South-east of England,' 8vo, 1833, pp. 307—10, Pls. II and III.

In the work entitled 'Wonders of Geology,' in which the author gives a miniature view of the parts of the skeleton of the Iguanodon, recomposed by Mr. Bensted and himself, he points out several "vertebræ of the back and tail," "ribs," "the two clavicles," "one of the bones (*radius*) of the fore-arm (subsequently recognised by Mr. G. B. Holmes, of Horsham, and by Dr. Mantell, as the humerus)," "two *metacarpal* bones," "the two ossa ilia," "the right and left thigh-bone, or *femur*," "a leg-bone, or *tibia*," "bones of the toes (*metatarsal* and *phalangeal*) of the hind feet." The parts marked "6" as metacarpals, are those named "*radius*" and "*ulna*" in T. XXXIV.

The femora measure each thirty-three inches in length, and one of them originally stood in a vertical position, as regards the strata, which are nearly horizontal; and it projected from the solid limestone bed, which embraced its lower extremity, and passed nearly through the superincumbent bed of sandstone. The author of the 'Notice of the Discovery of the Iguanodon in the Maidstone Quarry,'* infers from this circumstance a proof, "that these two beds, now so different in consistency, were, in the one case, '*loose sand*,' and in the other, '*tenacious mud*,' at the period when this shattered and decomposing body of the Iguanodon sank to the bottom of the sea, and became covered up by an abundant deposition." Dr. Buckland remarks, with reference to the discovery of this skeleton, in strata of the cretaceous period :—"That both the sand and the limestone are *marine* formations there can be no doubt; for though wood and vegetable substances are not uncommon in these beds, yet the limestone abounds in ammonites, shark's teeth, and other sea productions, while a small sea-shell was also found fixed upon one of the bones of the Iguanodon." Both strata of the Kentish Rag are now satisfactorily proved to belong to the neocomian or lower division of the Greensand formation, which intervenes between the Wealden and the upper Greensand. or in some parts of England between the Wealden and the Chalk. Dr. Buckland has remarked, in reference to this discovery of the Iguanodon, that it "shows that the

* 'Philos. Magazine,' loc. cit.

duration of this animal did not cease with the completion of the Wealden series. The individual from which this skeleton was derived had probably been drifted to sea, as those which afforded the bones found in the fresh-water deposits subjacent to this marine formation had been drifted into an estuary."*

One of the chief advantages of Mr. Bensted's remarkable discovery, is the demonstration which it affords of the vertebral characters of the Iguanodon,—an important evidence of organisation, the difficulty of obtaining which will be appreciated by reference to my 'Report on British Fossil Reptiles,'† in which descriptions of the various vertebræ that had been found in the Wealden up to the year 1841 are given.

In the point of view in which I have had this remarkable and unique collection of the remains of one and the same animal figured, there are four vertebræ with their bodies in natural juxtaposition at the upper corner opposite the right hand, and the same number a little dislocated at the lower corner of the slab. The latter show the characteristic neural arch in the best state of preservation, and the second of these vertebræ is represented of the natural size in T. XXXV.

In neither of these series, nor, indeed, in any part of the slab, is there a vertebra with a parapophysis, or articular tubercle or impression for a rib, upon the centrum,—a character indicative of one from the neck or anterior part of the thorax. The whole of the exposed outer surface of the centrum, save the two extremities, is smooth or "non-articular," as in the middle and hinder parts of the trunk in the Crocodilia. Both the terminal or articular surfaces of the centrum are slightly concave, and with a nearly circular contour, with the vertical diameter slightly predominating (T. XXXVI); the sides of the centrum rapidly contract as they recede from the articular ends towards the middle of the vertebra, and are chiefly remarkable for the almost plane surface which they form as they converge towards the lower surface of the centrum, the middle part of which is thus somewhat wedge-shaped, but with the lower border obtuse, and slightly concave lengthwise, as shown in T. XXXV.

The converging sides are, however, slightly convex vertically, more concave transversely; the free surface is traversed by fine longitudinal linear impressions. The neurapophyses have coalesced with each other, and the neural spine (*ns*) above, forming a remarkably broad and lofty neural arch, the base of which (*n n*) is still articulated by suture in this young Iguanodon to the centrum. In a few of the vertebræ this persistent suture has permitted a dislocation of the arch. The base of the neurapophysis is coextensive with the centrum lengthwise, and is developed inwards, transversely, so as almost to meet its fellow and circumscribe the neural canal. As the neurapophysis ascends it diminishes at first, in both diameters, and then again increases above the neural canal, and expanding above into a broad and strong platform, *n′ n′*, coalescing with its fellow, which surpasses the base of the neurapophysis

* Bridgwater Treatise, vol. i, p. 241.

† Transactions of the 'British Association,' 1844, pp. 84—133.

both in length and breadth. The platform is chiefly supported by a buttress-like ridge, which rises nearly vertically from the hinder and outer angle of the base of the neurapophysis, and gradually expands as it ascends, inclining a little forwards to blend with the under part of the overhanging platform. A transverse process, *p*, answering to the lower one or "*parapophysis*," in the vertebra of the Crocodile (T. V, fig. 3, *p*,)* extends from the side of the neurapophysis anterior to the buttress; its base presenting the form of an oval with the long axis vertical, and the small end upwards from which a smooth, convex prominence extends upwards and forwards, and subsides on the base of the anterior zygapophysis, which is developed from, or terminates, the fore-part of the neural platform. This transverse process is very short, and afforded an articular surface for the head of the rib. The second transverse process, answering to the upper one or "diapophysis" in the vertebra of the Crocodile (*d*, T. V, fig. 3)† which has been broken away in this specimen, is better preserved in the vertebra nearest the upper border of the slab in the T. XXXIII, and in a few other detached vertebræ. The anterior zygapophyses scarcely project as distinct processes from the neural platform, but seem to form the natural anterior boundary of that part; their thickness gradually diminishes to an edge anteriorly, and their flat oval articular surfaces look obliquely upwards and inwards. The posterior articular surfaces are developed from the under and back part of the neural platform, and look downwards and outwards, over-hanging the hinder surface of the centrum. This part of the neural arch has been somewhat crushed and depressed in the vertebra which best shows its characters amongst those in Mr. Bensted's specimen; but one may see that the plane from which the neural spine rises has sloped from behind downwards and forwards. The base of the neural spine is coextensive with the neural platform; from the middle line of which it rises, but it contracts as it ascends, and inclines backwards; its height is shown to equal that of the rest of the vertebra in one that lies between the humerus and femur; although it has there suffered fracture; in the other specimens the broken summits of the spines have not been preserved.

In the characters above defined we may plainly recognise a vertebra differing from any of those that have been previously described; from those of the Crocodiles and Gavials (T. IV, V, IX, and X)‡ in the flattened articular ends of the centrum; and by the same character from those of the Ophidian (T. XIII and XIV),§ and Lacertian (T. VIII, IX, and X)‖ reptiles which we have hitherto met with in the Tertiary and Cretaceous deposits; it is equally distinct from the biconical and short vertebræ of the Ichthyosaurus (T. XXII). Were the centrum of the Iguanodon's vertebra (T. XXXV) to be found detached from the neural arch, it might not be so easy to distinguish it from that of a dorsal vertebra of a *Plesiosaurus*, which is similarly

* Monograph on the Reptiles of the London Clay, pp. 33—36.

† Op. cit.

‡ Monograph on the Reptiles of the London Clay, Part ii.

§ Ib.

‖ Monograph on the Reptiles of the Cretaceous Formations.

characterised by nearly flattened articular extremities; but although the vertebræ are very variable in their proportions as to length and breadth in the different species of *Plesiosaurus*, I have hitherto found none that combine the same antero-posterior diameter with the nearly flattened, inferiorly converging, sides of the dorsal centrum, as in the Iguanodon. When, however, the entire vertebra can be compared, or the chief characters of the neural arch of the Iguanodon, with the tallying parts in the *Plesiosaurus*, important differences present themselves. In the cervical region of the *Plesiosaurus*, the neural arch is comparatively low and simple, and sends off no other processes save the zygapophyses and spine: in the dorsal region a diapophysis is superadded; but this alone offers an articular surface for the rib, and there is not any rudiment of parapophysis or of a parapophysial articulation for the head of the rib, such as is shown at *p*, T. XXXV. In the presence of this lower transverse process with the surface for the head of the rib, in the Iguanodon, developed either from the side of the centrum (as in the anterior dorsal vertebræ), or from the side of the neural arch (as in the middle dorsal vertebræ), we have a character* distinguishing it from *Ophidia*, *Lacertilia*, and *Enaliosauria*, whilst in the strong bony platform, in which the summit of the neural arch expands, with its supporting buttresses, we have an additional character distinguishing it from all known Crocodilia; and indicative of a distinct order of reptiles.

The importance of the characters deducible from Mr. Bensted's invaluable discovery, will be plainly manifested when the detached vertebræ and other fragmentary remains of large Saurians come to be described in the 'Monograph on the Wealden Reptiles,' and I proceed next to notice those of some caudal vertebræ which are well-preserved in the Maidstone specimen; they are marked '*c. vertebræ*' in T. XXXIV, and one of the most perfect is figured of the natural size in T. XXXVII. The centrum is more compressed than in the trunk, its articular ends are less expanded, but the flattened character of the inferiorly converging sides of the centrum being retained, this part presents in a more marked degree the wedge-shaped figure; the converging

* First made known in my 'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 127. "In the interspace of the two buttresses of the anterior dorsal vertebræ there is a large oval articular surface, convex at the anterior, and concave at the posterior part, which has afforded a lodgement to the head of the rib." The nature of the part affording this surface is described in the next page as "the transverse process" which "extends from the side of the neurapophysis." At the commencement of my 'Report' I defined the "transverse processes" as being "of two kinds, superior and inferior," (p. 48,) but I did not, in that 'Report,' specify them by the names "diapophysis" and "parapophysis:" the process in question for the head of the rib is the "parapophysis." The author of the Appendix to Dr. Mantell's Paper, in the 'Philosophical Transactions,' 1849, assuming the "upper transverse process" to be the one indicated in my description of the fractured vertebra, No. 2160, imputes to me what he conceives to be an error (p. 291); but the error lies in his assumption. It is one amongst many instances of the necessity of abandoning the vague term 'transverse process,' and the advantage and propriety of the definite names "diapophysis" and "parapophysis," which I have been in the habit of using since the publication of my 'Report' in 1841.

sides, however, are separated below by a broader quadrate tract which is slightly concave transversely, and more so lengthwise, with each of its angles developed into an articular hypapophysis, $y' \ y'$, for the junction of a portion of the base of a hæmal arch. This part, which is shown in T. XXXIII and XXXIV, near the middle of the upper border of the slab, consists, as usual, of a pair of "hæmapophyses," but they are confluent with one another, not only where they form the base of the long hæmal spine, but also at their opposite extremities; and the hinder hypapophysial surfaces, $y' \ y'$, which are the largest, also run into one another across the middle line. The articular end of the centrum, fig. 2 *c*, presents something between a quadrate and an elliptical form, with the long axis vertical; it is a little depressed within the border. The neural arch is anchylosed to the centrum; a rudiment of a parapophysis appears at the side of its base; the diapophysis rises above and behind this, and extends obliquely upwards, outwards, and backwards; its extremity is broken off. The zygapophyses, $z \ z$, figs. 1 and 2, are reduced to short tuberosities, without articular surfaces in this region of the spine; and the neural platform and its buttresses are quite suppressed. The summit of the neural spine is broken away.

Amongst the portions of ribs that are preserved, some show clearly not only the head but the neck and an articular tubercle; superadditions, which at once remove the *Iguanodon* from the *Iguana* and all its Lacertian congeners, and show the nearer affinity of the great Dinosaur to the Crocodiles; in one of the specimens near the upper part of the slab, as figured in T. XXXIII, there is an indication of the upper part of the neck of the rib rising and bifurcating near the tubercle, whence it is continued as two ridges which form an anterior and posterior margin, as it were produced and overhanging the body of the rib. This character may not be without its value in detecting and determining fragments of ribs, which are common among the fossils of the strata containing the remains of great reptiles.

Both the bones, answering to those from the Wealden of Tilgate, which Cuvier thought "might be a clavicle,"* are preserved in the Maidstone specimen, having the same long, slender, triedral shaft slightly expanded, flattened and bent at one extremity; more expanded, flattened, and bent at an open angle at the opposite end; with a short pointed process sent off at the angle, and a broad subquadrate flattened plate projecting from the same border of the bent and expanded end, which has a truncate termination. In the *Cyclodus*† lizard I find the clavicle is bent at an open angle, but nearer its middle part; and the difference between this and the nearly

* Quoted by Dr. Mantell, in 'Geology of the South-East of England,' 1833, p. 308.

† This is the Lizard referred to in the following passage of Dr. Mantell's Paper, in the 'Philosophical Transactions,' 1841, p. 138. "In a very small Lizard in the Hunterian Museum, Mr. Owen pointed out to me a bone attached to the coracoid and omoplate, that bore some analogy to the one in question:" it bears sufficient analogy to support the conclusion in the text, but lends no countenance whatever to the idea of the fossil in question being a peculiar superaddition to the Saurian skeleton, requiring a new name. The "os Cuvieri" is, in fact, abandoned in the Paper, in the 'Phil. Trans.,' 1849.

straight clavicle of the *Iguana*, *Amblyrhynchus*, and some other lizards, justifies the expectation of some unexampled modifications of that variable bone in a great extinct reptile of a different order.

For a knowledge of the bone, called "scapula" and "humerus," in T. XXXIV, I am indebted to Mr. George B. Holmes, of Horsham, who, in March, 1847, transmitted to me a beautiful drawing of both bones, together with the coracoid in natural juxtaposition with the humerus, discovered "in one block of stone, with other bones of the same individual" in Tower Hill Pit, near Horsham. That gentleman, whose collection of the Wealden Fossils in his neighbourhood is one of the most instructive extant, had correctly determined their nature, and named them in the drawing which he sent to me "Humerus, Scapula, and Coracoid bone of the Iguanodon."

Dr. Mantell published similar determinations of homologous bones, in the 'Philosophical Transactions' for 1849. This part of the skeleton of Iguanodon may, therefore, be regarded as definitely restored.

The scapula in the Maidstone specimen, T. XXXIII, lies broken across the femur: it is a long, narrow, flattened bone gradually expanding to its free end, more suddenly towards its articular end; but this is too much mutilated to give its true character in the specimen in question: it will be described from Mr. Holmes's beautiful specimen in the 'Monograph of the Fossil Reptiles of the Wealden.'

The humerus (see T. XXXIV) is shorter than the scapula, and much shorter than the femur, its relative proportions to which are the same in the Iguanodon, as in the Teleosaurus (see T. XI, Monograph on the Crocodilia of the London Clay), and, with the vertically developed tail of the Iguanodon indicate the aquatic habits of that gigantic reptile. The head of the humerus is hemispheroid, and projects between two sub-equal tuberosities; a deltoid ridge is continued nearly half way down the bone from the outer tuberosity, and, where it subsides, the shaft is bent a little inwards, contracts, and then again expands to the distal condyles, which are rounded and prominent, with a moderately deep depression between them at the back, which is the part of the bone exposed in the Maidstone specimen.

The radius and ulna lie with their proximal ends next the right hand upper corner of the slab of the Maidstone specimen; the latter being distinguished by its prominent olecranon, which is rounded as in the great Monitor (*Varanus niloticus*). I shall reserve the description of the metacarpal and metatarsal bones for a succeeding Monograph, and shall only observe, here, that the claw-bones marked "ungual phalanx" in T. XXXIV, though varying in their proportions in the two specimens preserved, are broader, more depressed, and less incurved than those of other known Saurians.

The ilium which lies detached near the lower border of the slab in the Maidstone specimen, is the left one, with its sacral articular surface or inner surface uppermost, the extent of which plainly indicates the great length of the sacrum in the Iguanodon, as compared with existing Lizards, since it equals the antero-posterior diameter of five

of the dorsal vertebræ ; the part of the bone which is prolonged backwards beyond the articular part is slender, and terminates in an obtuse point. The right ilium, which is overlapped by one of the clavicles, shows that the anterior end bends outwards in the form of a thick tuberosity, and the expanded portion contributes by its lower border the usual share in the formation of the acetabulum.

The two *femora* (T. XXXIV, *femur*) well exemplify the characteristic peculiarities of this bone in the Iguanodon: its inwardly projecting hemispheric head, its much flattened trochanter, the compressed ridge-like process from the middle of the inner surface of the shaft, and the deep and narrow fissure between the distal condyles. This part of the femur had been figured and referred by Dr. Mantell to the Iguanodon, in his 'Geology of the South-East of England,' Nov. 1833, p. 310, pl. IV, figs. 3 and 4; and the subsequent discovery of the Maidstone specimen confirmed the accuracy of that determination.

The bone which is figured in Pl. II, fig. 8 of the same work, as the tibia of the Iguanodon, is also shown to be correctly so called by the Maidstone specimen, T. XXXIII and T. XXXIV.

The following are the dimensions of the principal and best-preserved bones in that specimen:—

Dorsal Vertebræ.

	Inches.	Lines.
Antero-posterior diameter of centrum	3	10
Vertical diameter of articular end	4	0
Transverse diameter of ditto	3	1
From the base of the neurapophysis to the fore-part of that of the spinous process	3	0
From ditto ditto back part of ditto	4	0
Antero-posterior extent of neural platform	4	6

Caudal Vertebræ.

	Inches.	Lines.
Antero-posterior diameter of centrum	2	5
Vertical diameter of articular end	2	5
Transverse diameter of ditto	1	11
From the base of the neurapophysis to the fore-part of that of the spinous process	1	3
From ditto ditto back part of ditto	1	6

Clavicle.

	Inches.	Lines.
Length of the bone	37	0
Breadth across the process at the broader end	8	0
Breadth across the narrower end	4	0

Scapula.

	Inches.	Lines.
Length of the bone	29	0
Breadth across the middle of the shaft	3	0

Humerus.

Length	19	0
Breadth of proximal end	6	0
Breadth of distal end	4	0

Ulna.

Length	18	0
Breadth of proximal end	3	0

Ilium.

Length	30	0
Breadth across the enlarged end	10	0
Extent of sacro-iliac articulation	19	0

Femur.

Length	33	0

Tibia.

Length	31	0

The detached teeth and bones of the Iguanodon successively discovered in the Wealden strata of Sussex, and afterwards found associated together to the extent of nearly half the skeleton of one and the same individual in the Green-sand quarries of Mr. Bensted, offer not the least marvellous or significant evidences of the inhabitants of the now temperate latitudes during the later secondary periods of the formation of the earth's crust.

With vertebræ subconcave at both articular extremities, having, in the dorsal region, lofty and expanded neural arches, and doubly articulated ribs, and characterised in the sacral region by their unusual number and complication of structure; with a Lacertian pectoral arch, crocodilian proportions of the fore-limbs, and unusually large bones of the hind limbs, excavated by large medullary cavities and adapted for terrestrial progression, as well as for natation;—the *Iguanodon* was distinguished by

teeth, resembling in shape those of the Iguana, but in structure differing from the teeth of that and every other known reptile, and unequivocally indicating the former existence in the Dinosaurian Order of a gigantic representative of the small group of living lizards which subsist on vegetable substances.

The important difference which the fossil teeth presented in the form of their grinding surface was pointed out by Cuvier,* of whose description Dr. Mantell adopted a condensed view in his 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 72. The combination of this dental distinction with the vertebral and costal characters, which prove the *Iguanodon* not to have belonged to the same group of Saurians as that which includes the Iguana and other modern lizards, rendered it highly desirable to ascertain by the improved modes of investigating dental structure, the actual amount of correspondence between the *Iguanodon* and Iguana in this respect. This I have done in my general description of teeth of reptiles,† from which the following description is abridged:—

The teeth of the *Iguanodon*, though resembling most closely those of the Iguana, do not present an exact magnified image of them, but differ in the greater relative thickness of the crown, its more complicated external surface, and, still more essentially, in a modification of the internal structure, by which the *Iguanodon* equally deviates from every other known reptile.

As in the Iguana, the base of the tooth is elongated and contracted; the crown expanded, and smoothly convex on the inner side; when first formed it is acuminated, compressed, its sloping sides serrated, and its external surface traversed by a median longitudinal ridge, and coated by a layer of enamel, but beyond this point the description of the tooth of the *Iguanodon* indicates characters peculiar to that genus. In most of the teeth that have hitherto been found, three longitudinal ridges traverse the outer surface of the crown, one on each side of the median primitive ridge; these are separated from each other, and from the serrated margins of the crown by four wide and smooth longitudinal grooves. The relative width of these grooves varies in different teeth; sometimes a fourth small longitudinal ridge is developed on the outer side of the crown. The marginal serrations, which at first sight appear to be simple notches, as in the Iguana, present under a low magnifying power the form of transverse ridges, themselves notched, so as to resemble the mammillated margins of the unworn plates of the elephant's grinder: slight grooves lead from the interspaces of these notches upon the sides of the marginal ridges. These ridges or dentations do not extend beyond the expanded part of the crown: the longitudinal ridges are continued further down, especially the median ones, which do not subside till the fang of the tooth begins to assume its subcylindrical form. The tooth at first increases both in breadth and thickness; it then diminishes in breadth, but its thickness goes on

* Ossemens Fossiles, 1824, vol. v, part ii, p. 351.

† Odontography, part ii, p. 249; and Transactions of the British Association, 1838.

increasing; in the larger and fully formed teeth, the fang decreases in every diameter, and sometimes tapers almost to a point. The smooth unbroken surface of such fangs indicates that they did not adhere to the inner side of the maxillæ, as in the Iguana, but were placed in separate alveoli, as in the Crocodile and Megalosaur: such support would appear, indeed, to be indispensable to teeth so worn by mastication as those of the *Iguanodon*.

The apex of the tooth soon begins to be worn away; and it would appear, by many specimens that the teeth were retained until nearly the whole of the crown had yielded to the daily abrasion. In these teeth, however, the deep excavation of the remaining fang plainly bespeaks the progress of the successional tooth prepared to supply the place of the worn out grinder. At the earlier stages of abrasion a sharp edge is maintained at the external part of the tooth by means of the enamel which covers that surface of the crown; the prominent ridges upon that surface give a sinuous contour to the middle of the cutting edge, whilst its sides are jagged by the lateral serrations: the adaptation of this admirable dental instrument to the cropping and comminution of such tough vegetable food as the *Clathrariæ* and similar plants, which are found buried with the *Iguanodon*, is pointed out by Dr. Buckland, with his usual felicity of illustration, in his 'Bridgewater Treatise,' vol. i, p. 246.

When the crown is worn away beyond the enamel, it presents a broad and nearly horizontal grinding surface, and now another dental substance is brought into use to give an inequality to that surface; this is the ossified remnant of the pulp, which, being firmer than the surrounding dentine, forms a slight transverse ridge in the middle of the grinding surface: the tooth in this stage has exchanged the functions of an incisor for that of a molar, and is prepared to give the final compression, or comminution, to the coarsely divided vegetable matters.

The marginal edge of the incisive condition of the tooth, and the median ridge of the molar stage, are more effectually established by the introduction of a modification into the texture of the dentine, by which it is rendered softer than in the existing Iguanæ and other reptiles, and more easily worn away: this is effected by an arrest of the calcifying process along certain cylindrical tracts of the pulp, which is thus continued, in the form of medullary canals, analogous to those in the soft dentine of the Megatherium's grinder, from the central cavity, at pretty regular intervals, parallel with the calcigerous tubes, nearly to the surface of the tooth. The medullary canals radiate from the internal and lateral sides of the pulp cavity, and are confined to the dentine forming the corresponding walls of the tooth: their diameter is $\frac{1}{1250}$th of an inch: they are separated by pretty regular intervals equal to from six to eight of their own diameters; they sometimes divide once in their course. Each medullary canal is surrounded by a clear space; its cavity was occupied in the section described by a substance of a deeper yellow colour than the rest of the dentine.

The calcigerous tubes present a diameter of $\frac{1}{25,000}$th of an inch, with interspaces

equal to about four of their diameters. At the first part of their course, near the pulp cavity, they are bent in strong undulations, but afterwards proceed in slight and regular primary curves, or in nearly straight lines to the periphery of the tooth. When viewed in a longitudinal section of the tooth, the concavity of the primary curvature is turned towards the base of the tooth: the lowest tubes are inclined towards the root, the rest have a general direction at right angles to the axis of the tooth; the few calcigerous tubes, which proceed vertically to the apex, are soon worn away, and can be seen only in a section of the apical part of the crown of an incompletely developed tooth. The secondary undulations of each tooth are regular and very minute. The branches, both primary and secondary, of the calcigerous tubes are sent off from the concave side of the main inflections; the minute secondary branches are remarkable at certain parts of the tooth for their flexuous ramifications, anastomoses, and dilatations into minute calcigerous cells, which take place along nearly parallel lines for a limited extent of the course of the main tubes. The appearance of interruption in the course of the calcigerous tubes, occasioned by this modification of their secondary branches, is represented by the irregularly-dotted tracts in the figure. This modification must contribute, with the medullary canals, though in a minor degree, in producing that inequality of texture and of density in the dentine, which renders the broad and thick tooth of the *Iguanodon* more efficient as a triturating instrument.

The enamel which invests the harder dentine, forming the outer side of the tooth, presents the same peculiar dirty brown colour, when viewed by transmitted light, as in most other teeth: very minute and scarcely perceptible undulating fibres, running vertically to the surface of the tooth, form the only structure I have been able to detect in it.

The remains of the pulp in the contracted cavity of the completely-formed tooth, are converted into a dense but true osseous substance, characterised by minute elliptical radiated cells, whose long axis is parallel with the plane of the concentric lamellæ, which surround the few and contracted medullary canals in this substance.

The microscopical examination of the structure of the Iguanodon's teeth thus contributes additional evidence of the perfection of their adaptation to the offices to which their more obvious characters had indicated them to have been destined.

To preserve a trenchant edge, a partial coating of enamel is applied; and, that the thick body of the tooth might be worn away in a more regularly oblique plane, the dentine is rendered softer as it recedes from the enameled edge by the simple contrivance of arresting the calcifying process along certain tracts of the inner wall of the tooth. When attrition has at length exhausted the enamel, and the tooth is limited to its function as a grinder, a third substance has been prepared in the ossified remnant of the pulp to add to the efficiency of the dental instrument in its final capacity. And if the following reflections were natural and just after a review of the external characters

of the dental organs of the *Iguanodon,* their truth and beauty become still more manifest as our knowledge of their subject becomes more particular and exact.

"In this curious piece of animal mechanism we find a varied adjustment of all parts and proportions of the tooth, to the exercise of peculiar functions, attended by compensations adapted to shifting conditions of the instrument, during different stages of its consumption. And we must estimate the works of nature by a different standard from that which we apply to the productions of human art, if we can view such examples of mechanical contrivance, united with so much economy of expenditure, and with such anticipated adaptations to varying conditions in their application, without feeling a profound conviction that all this adjustment has resulted from design and high intelligence."—('Buckland's Bridgewater Treatise,' vol. i, p. 249.)

C. AND J. ADLARD, PRINTERS, BARTHOLOMEW CLOSE.

TAB. I.

Chelone Benstedi, nat. size.

Fig.

1. Upper view of the carapace.
2. Side view of the carapace.

The letters and figures are explained in the text.

From the Middle Chalk, Kent. In the Museum of Dr. Mantell, F.R.S.

Fig. 1

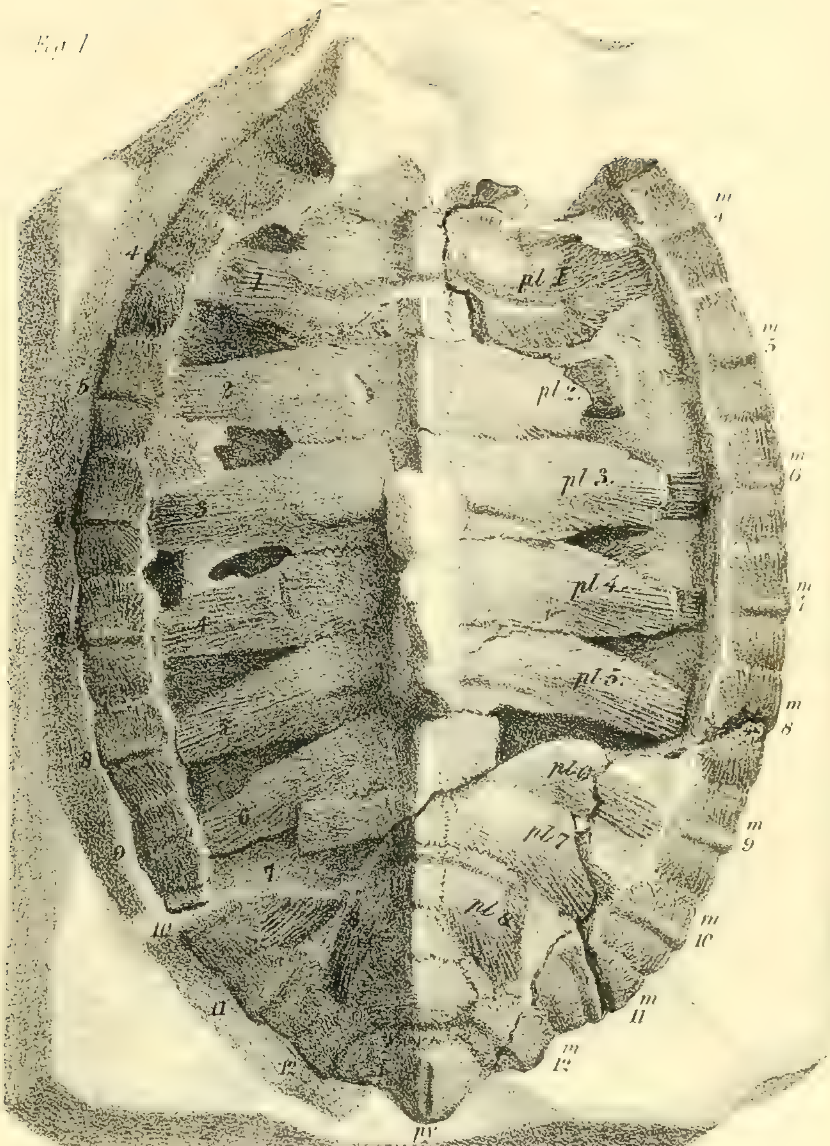


Fig. 2

Chelone Benstedi.

Dinkel del.

TAB. II.

Chelone Benstedi, nat. size.

Fig.

1. Under view of the carapace.

2. Upper view, with the part of the carapace removed to show the bones of the plastron and coracoid.

From the Middle Chalk, Kent. In the Museum of Dr. Mantell, F.R.S.

T. II.

Fig. 1

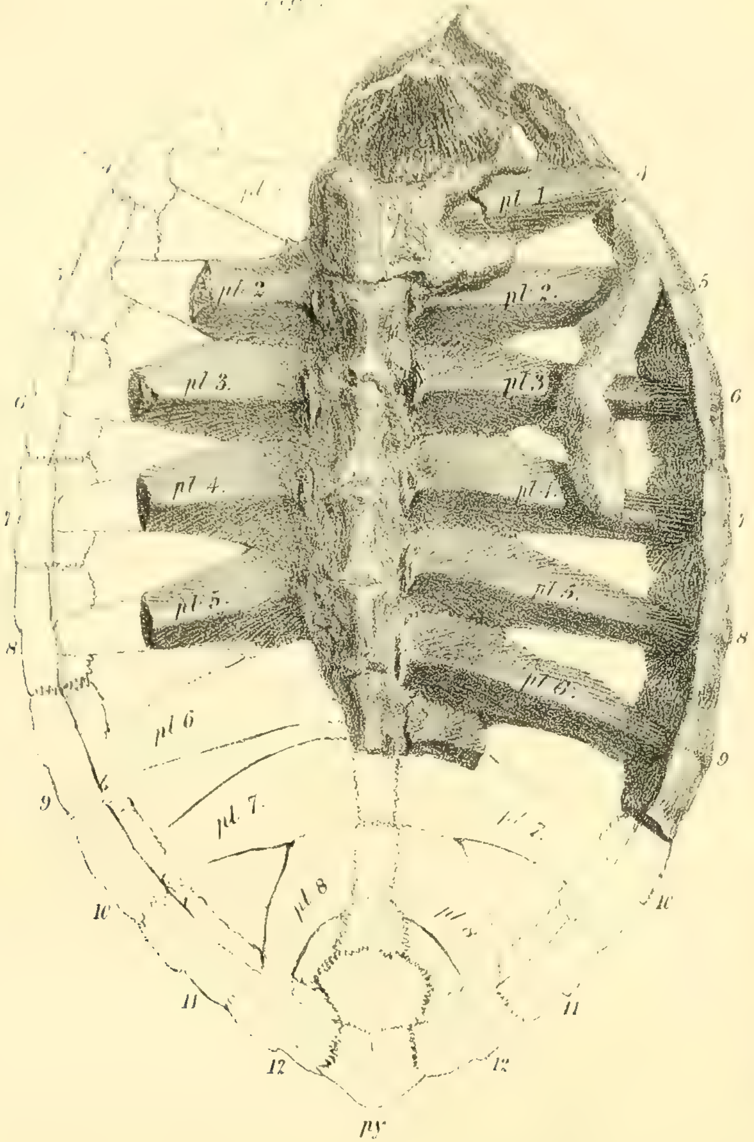
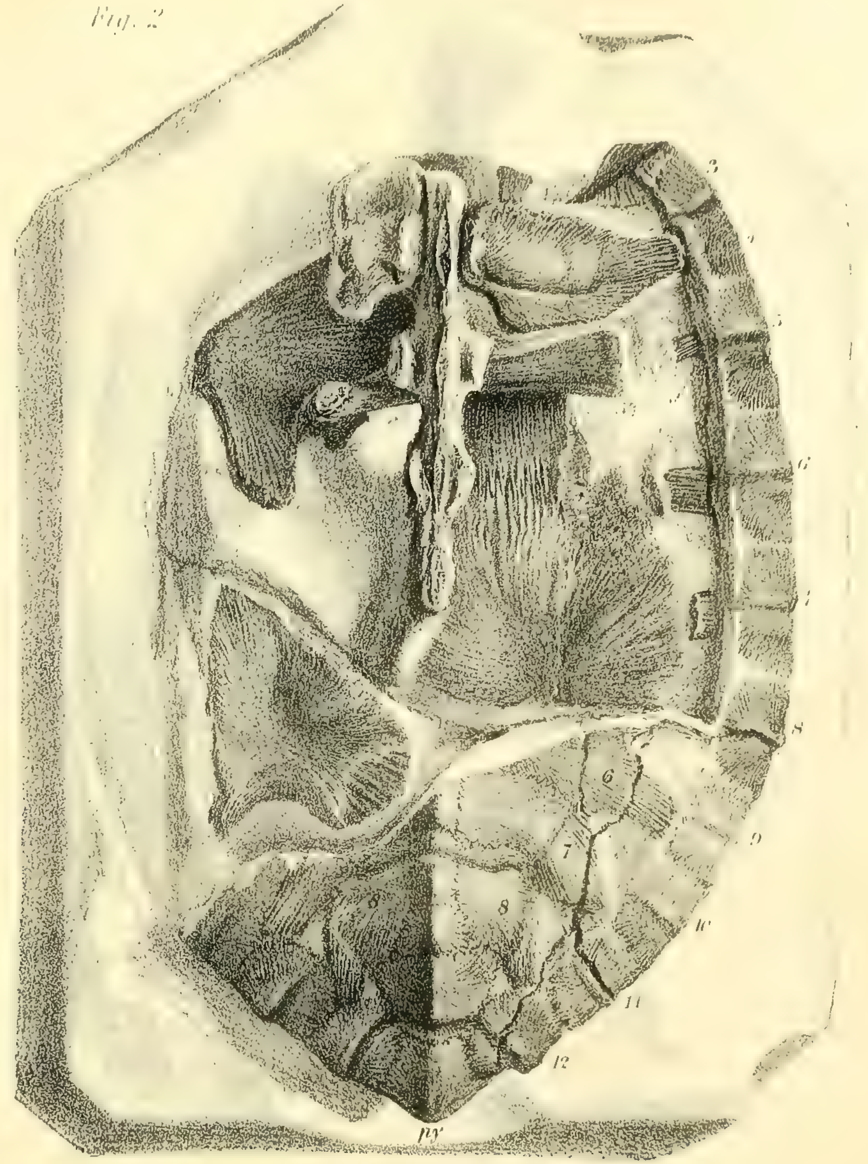


Fig. 2



Chelone Benstedi.

Dinkel sc. et lith

TAB. III.

Chelone Benstedi, nat. size.

Fig.
1. Upper view of the carapace.
2. Side view of the carapace.
3. Oblique view of fore-part and left side of the carapace.
4. Outline of transverse section of the carapace.

From the Middle Chalk, Kent. In the Museum of J. S. Bowerbank, Esq., F.R.S.

Fig 1

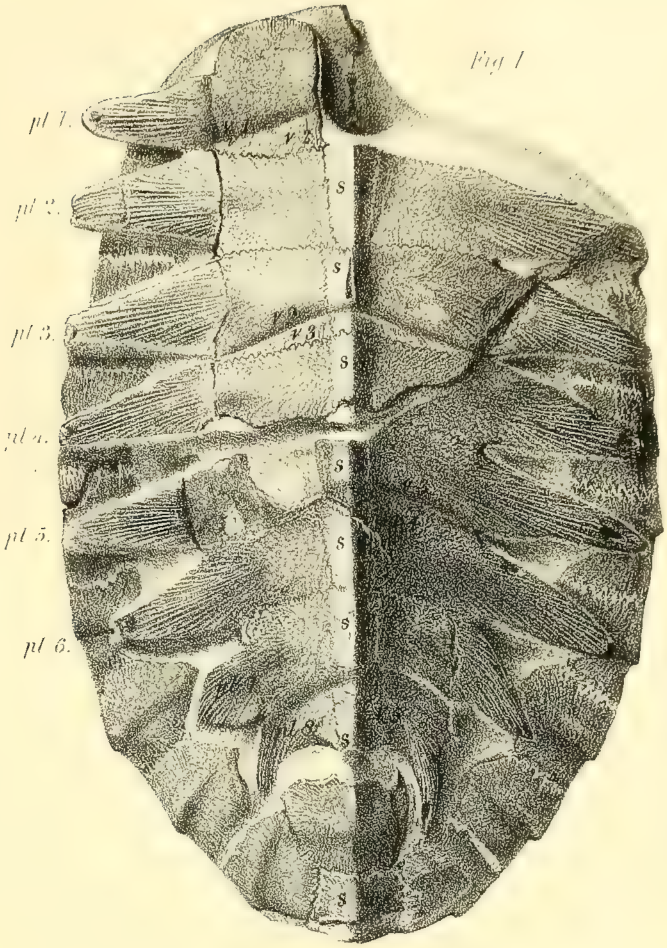


Fig. 2

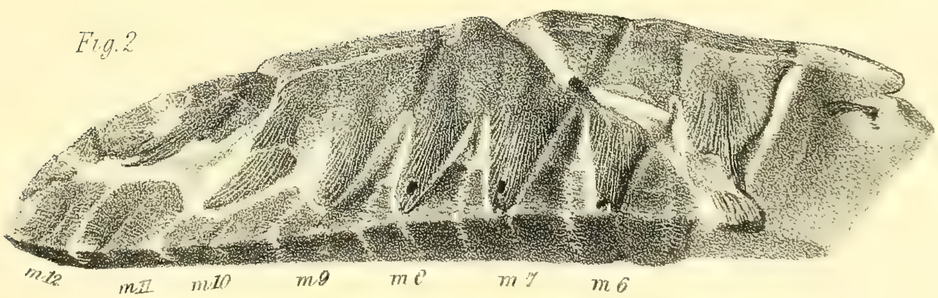


Fig 3.

Fig 4.

Chelone Bensledi.

Jos Dinkel, del et lith

Day & Son, Lith^rs to The ...

TAB. IV.

Fig.

1—10, 13—16. Teeth of *Ichthyosaurus campylodon*.

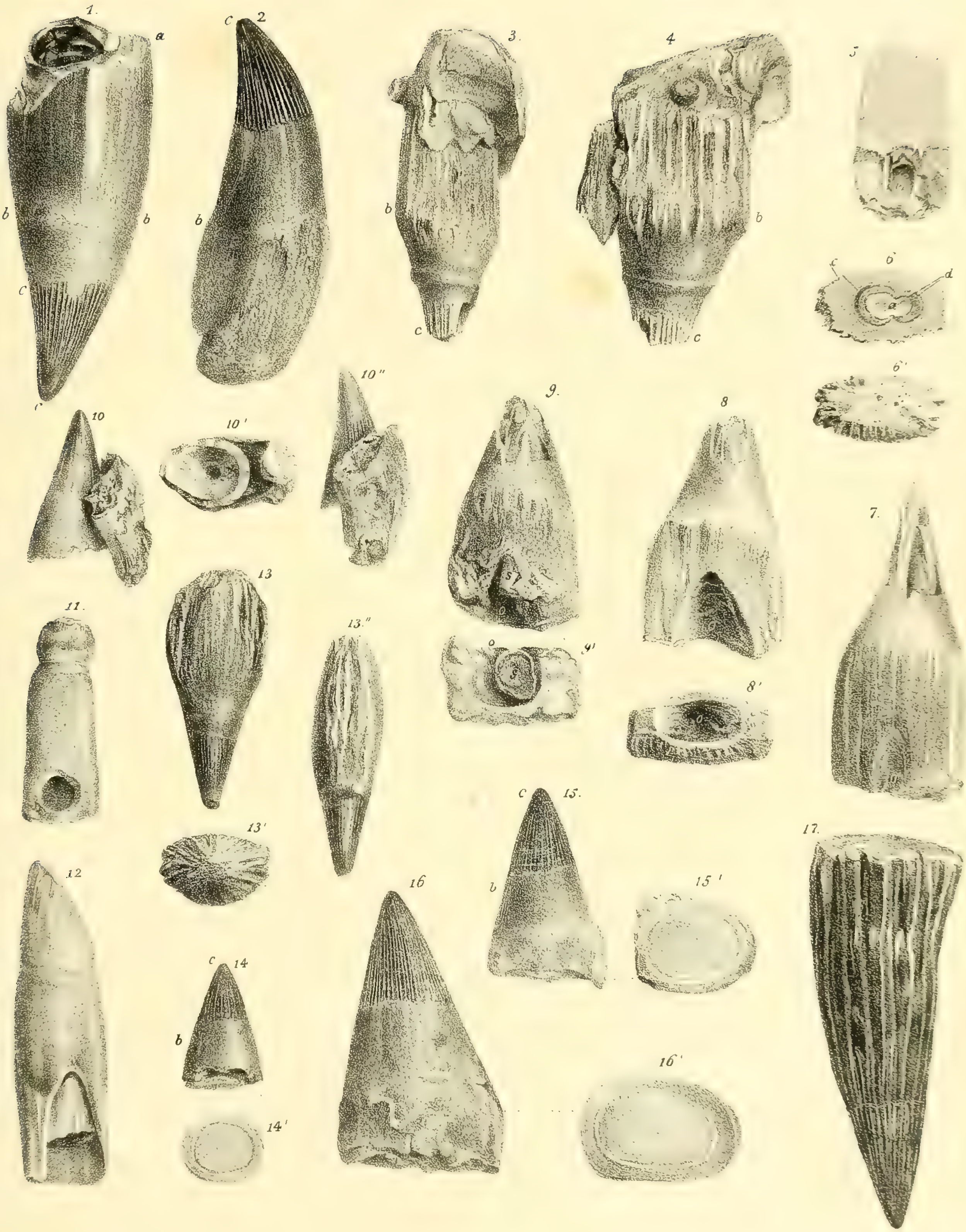
From the Chalk and Green-sand of Cambridgeshire. In the Collection of James Carter, Esq., of Cambridge.

11. Back tooth of a recent Alligator, showing the circular hole made by the absorption consequent on the pressure of a young tooth.

12. Tooth of a recent Crocodile, showing the young tooth, that has penetrated the pulp-cavity of the old tooth.

17. Tooth of *Ichthyosaurus communis*, from the Lias of Lyme Regis.

All the figures are of the natural size.



TAB. V.

Chelone Camperi, nat. size.

Fig.

1. External surface of two dermal plates, probably "marginal" ones.

2. Transverse section of one of the above, and of a subjacent inverted plate.

From the Upper Chalk of Kent. In the Museum of Thomas Charles, Esq., of Maidstone.

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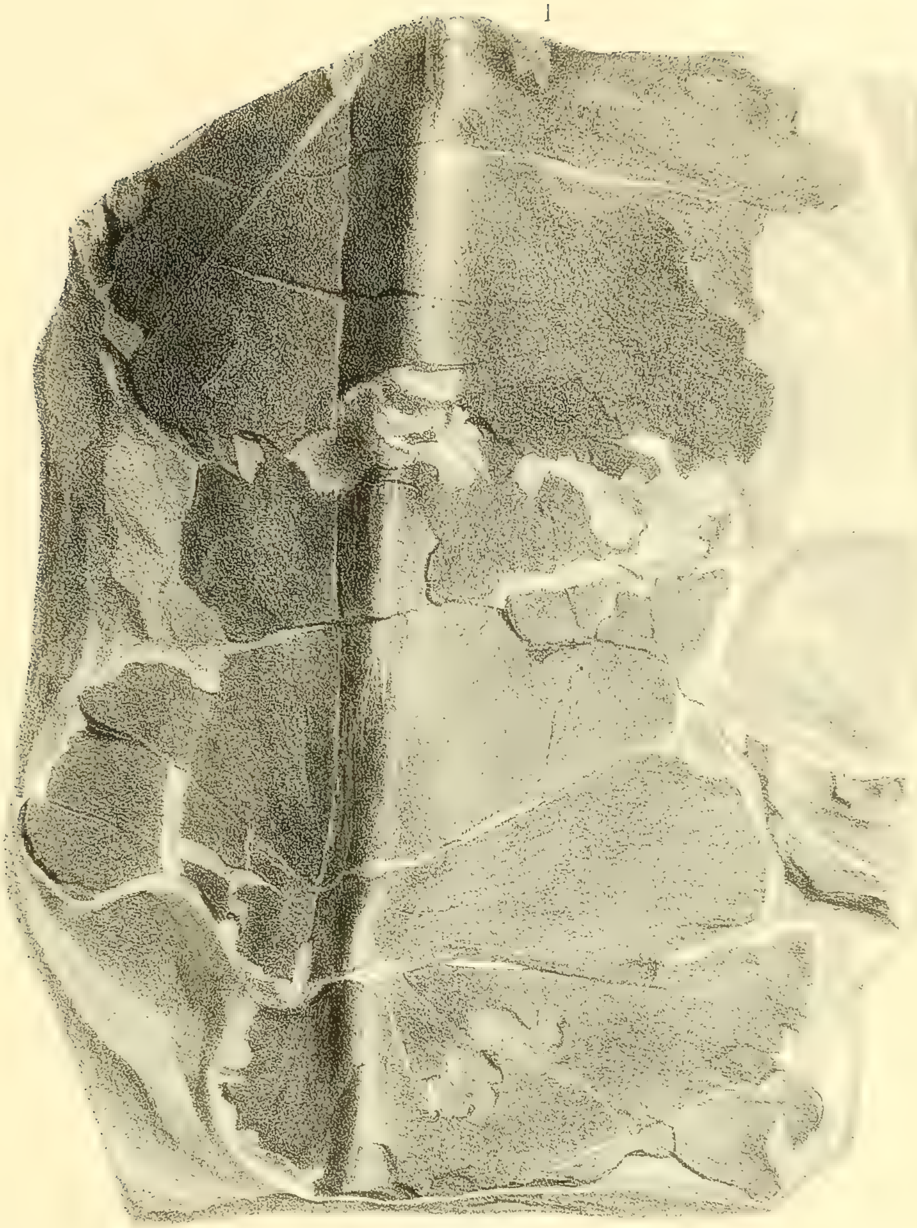

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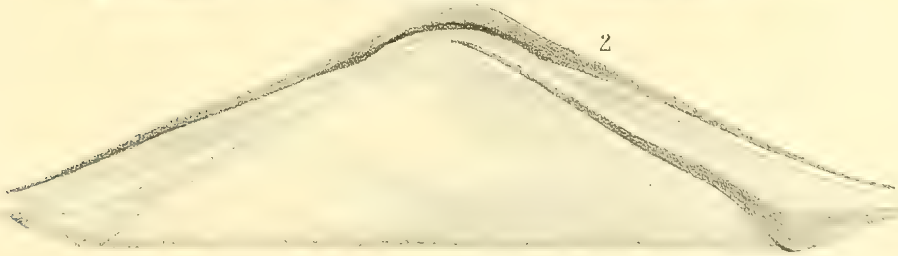


Chelone Camperi.

From Nature on Stone by J. Erxleben

Day & Son, Lithrs to the Queen

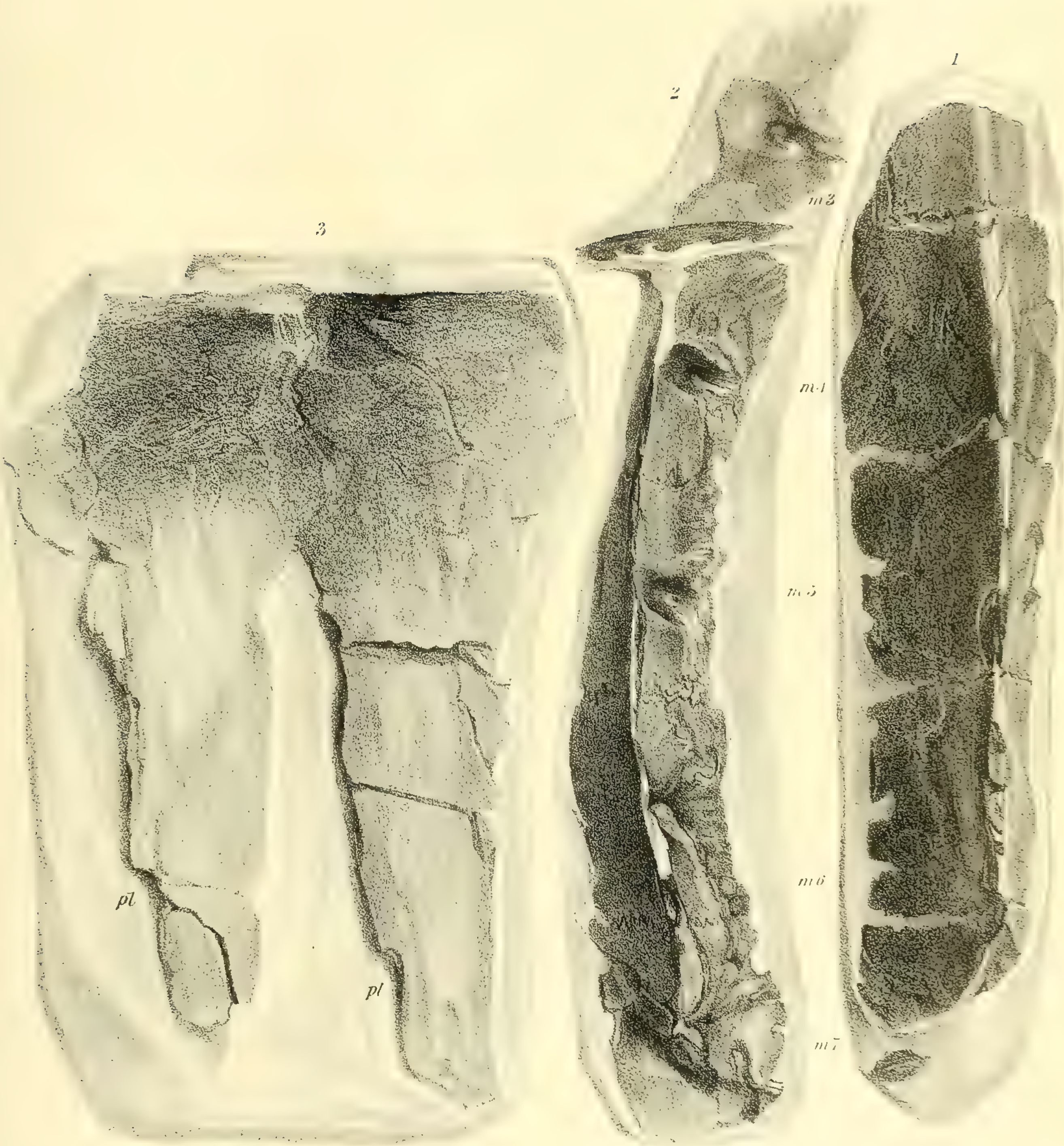
TAB. VI.

Chelone Camperi (?), nat. size.

Fig.

1. Outer surface of a series of five "marginal" plates.
2. Inside view of the same.
3. Portions of two ribs of the carapace of apparently the same species of Turtle.

From the Middle Chalk of Kent. In the Museum of Mrs. Smith, of Tonbridge Wells.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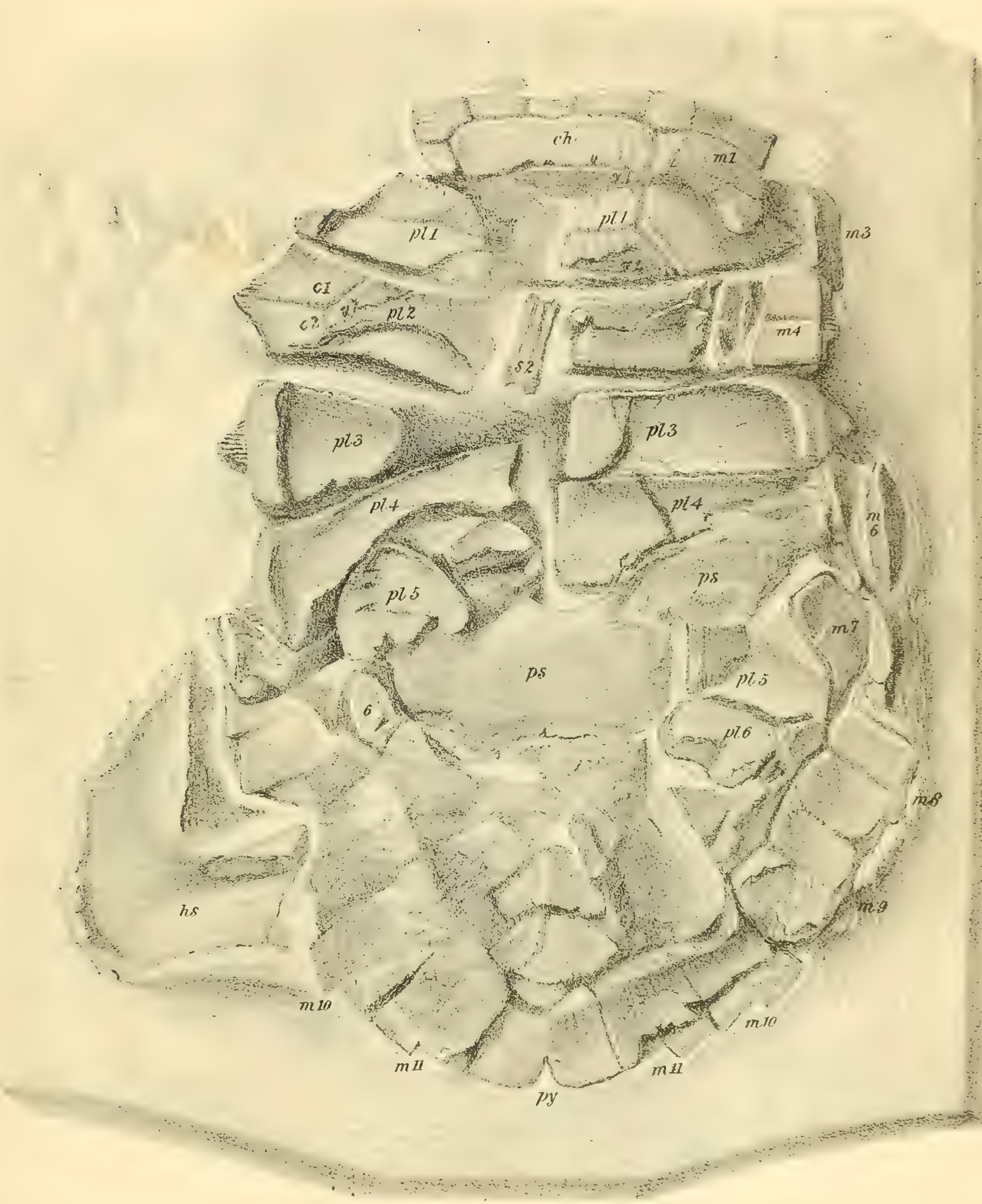
TAB. VII.

Protemys serrata, half nat. size.

Upper surface of the carapace.

The letters and figures signify the same parts as in the preceding Monograph.

From the "Kentish Rag," Green-sand Formation, Maidstone. In the Collection of Capt. Guise, F.G.S.



J. Dinkel del et lith.

Day & Son, lith^rs to the Queen

TAB. VII *A*.

Fig.

1. Upper view of the skull of *Chelone pulchriceps*, nat. size.
2. Side view of ditto ditto.
3. Under view of ditto ditto.

7. Parietal.
8. Mastoid.
11. Frontal.
12. Post-frontal.
14. Pre-frontal.
15. Nasal.
20. Palatine.
21. Maxillary.
22. Premaxillary.
24. Pterygoid.

From the Green-sand, Barnwell, Cambridgeshire. In the Collection of the Rev. Thomas Image, M.A., of Whepstead.

4. Upper view of the mandible of a *Chelonian*.
5. Side view of the same mandible, nat. size.
6. Under view of the mandible of another species of Chelonian.
7. Side view of the same mandible, nat. size.
8. A marginal plate of the carapace of a Turtle (*Chelone*).

The above three specimens are from the Chalk of Kent: and are in the collection of James Scott Bowerbank, Esq., F.R.S.

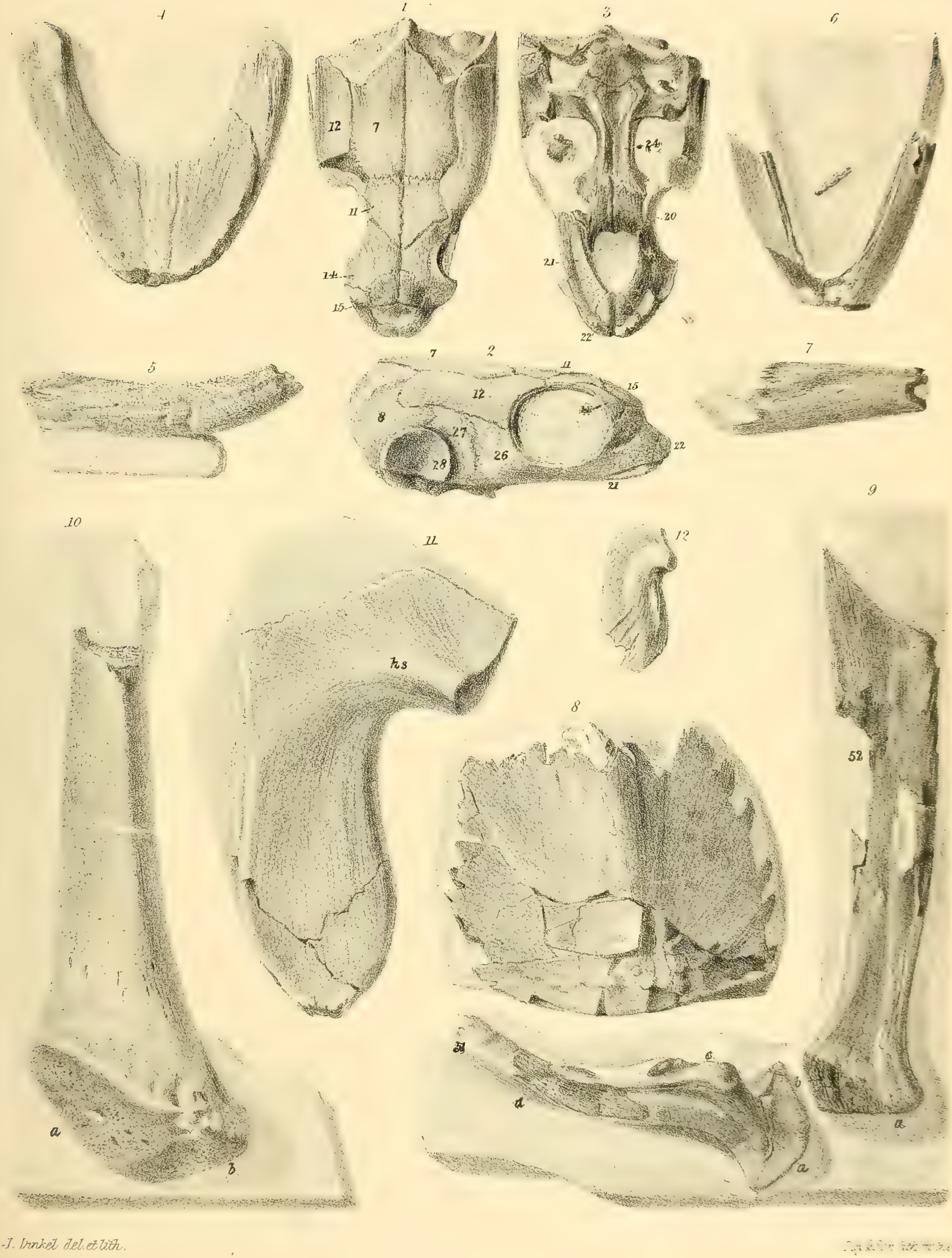
9. The scapula 51, and coracoid 52, of a Turtle (*Chelone*).

From the Chalk of Sussex. In the Collection of Henry Catt, Esq., of Brighton.

10. Part of the coracoid of a Turtle (*Chelone*).

From the Burham Chalk-pit, Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.

11. The upper or inner surface of the left hyosternal bone of *Protemys serrata*, nat. size. From the same specimen as the subject of T. VII.
12. The left hyosternal bone of an immature *Emys*, similarly mutilated of its inner process.



J. Dinkel del. et lith.

TAB. VIII.

Mosasaurus gracilis, nat. size.

Fig.

1. Side view of a hinder dorsal vertebra.
2. Back view of ditto.
3. Two caudal vertebræ.

From the Upper Chalk, near Lewes. In the Mantellian Collection. British Museum.

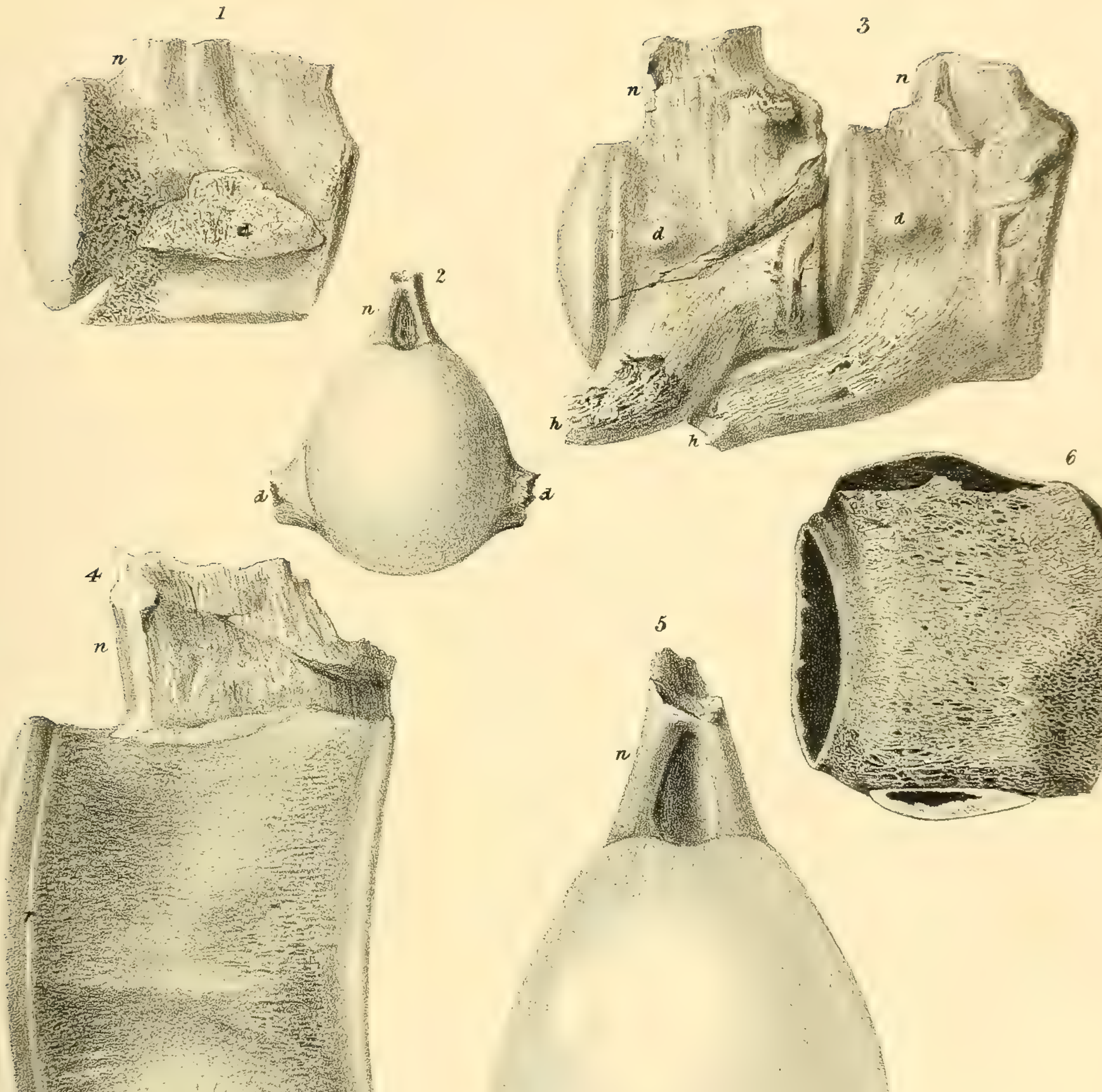
Mosasaurus Hoffmanni.

4. Side view of a hinder dorsal vertebra, nat. size.
5. Back view of ditto.

From the Cretaceous Beds, at Maestricht. In the British Museum.

6. The half of a vertically and longitudinally bisected vertebral centrum of a *Mosasaurus gracilis*, which was partially enclosed in a nodule of flint, from the Upper Chalk, at Kemptown, Brighton. The siliceous matter has infiltrated itself into much of the cellular structure of the middle part of the centrum. The densest part of the cellular structure is near the concave surface of the vertebra.

In the Collection of Dr. Mantell, F.R.S., by whose obliging permission it is figured for the present Monograph.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TAB. IX.

Fig.

1. Part of the lower jaw of *Mosasaurus gracilis*, nat. size.

1*a*. Part of the upper jaw of ditto.

2. Body of a lumbar vertebra of ditto.

3. Body of a dorsal vertebra of ditto.

4. Anterior concave surface of the same vertebra.

5. Anterior view of a mutilated caudal vertebra, showing the much expanded hæmal arch *e*.

From the Upper Chalk, at Offham-pit, Sussex. In the Collection of Henry Catt, Esq., of Brighton.

6. Under view of the body of a cervical vertebra of *Plesiosaurus constrictus*.

7. End view of the same vertebra.

From the Steyning Chalk-pit, Sussex.

8. Tooth of a *Plesiosaurus*.

From the Scaddlescombe Chalk-pit, near Lewes, Sussex.

9. Tooth of a *Plesiosaurus*.

From the Southeram Chalk-pit, Sussex.

10. Tooth of a *Plesiosaurus*.

From the Southeram Chalk-pit, Sussex.

11. Tooth of *Polyptychodon interruptus*.

12. Base of the same tooth.

From the Chalk, near Valmer, Lewes.

13. Nine dorsal vertebræ of a Lizard (*Coniosaurus crassidens*).

14. Part of the lower jaw and some attached vertebræ of *Coniosaurus crassidens*.

14*a*. A magnified tooth of ditto.

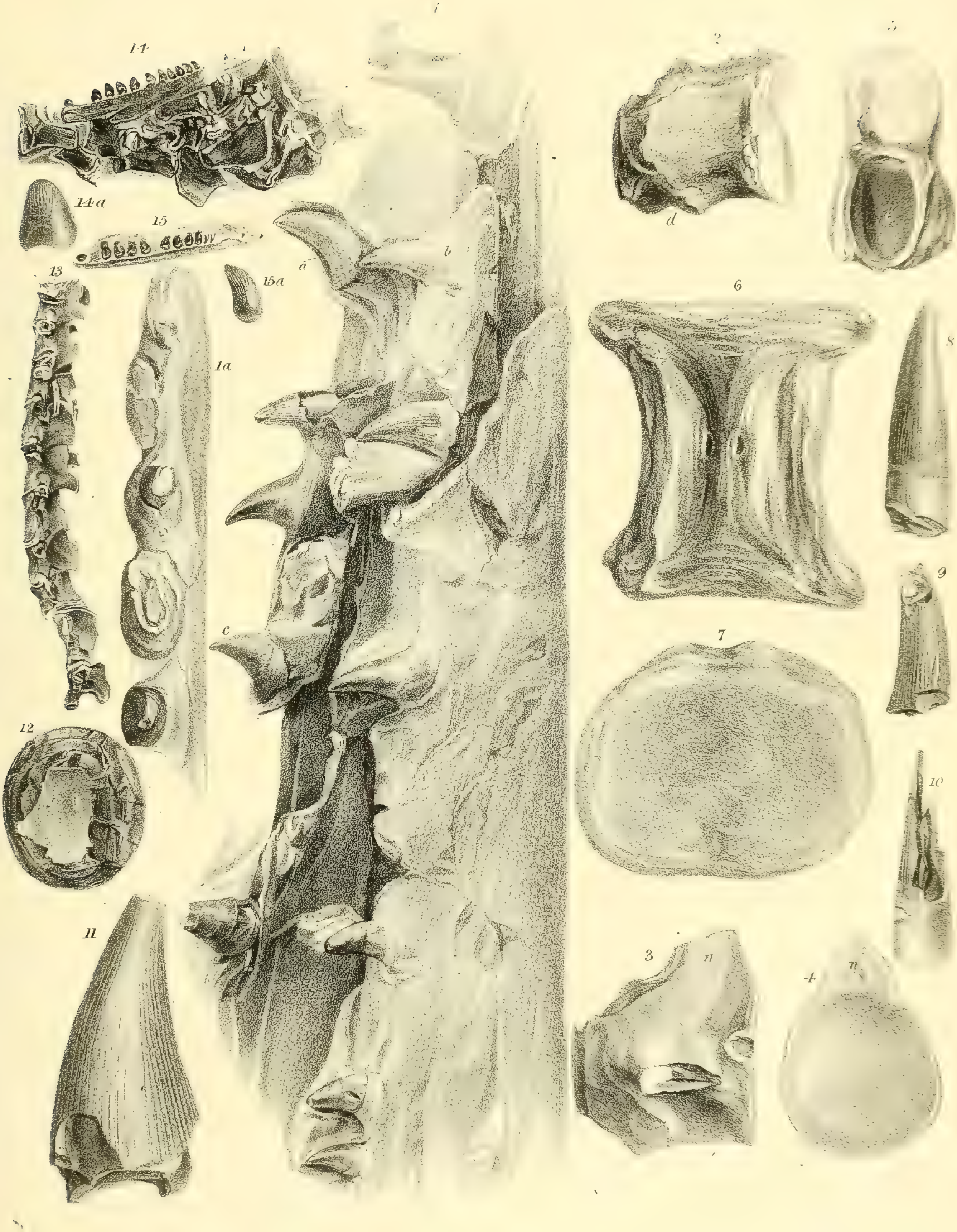
15. View of part of the alveolar groove and teeth of ditto.

15*a*. A magnified hinder tooth of ditto.

From the Lower Chalk at Clayton, Sussex. In the Collection of Henry Catt, Esq., of Brighton.

All the figures are of the natural size.

T. IV



TAB. IX *A*.

Leiodon anceps, nat. size.

Fig.

1. Part of the lower jaw with teeth.

2. Diagrammatic section of a tooth, showing the pulp-cavity, which contained a siliceous mass, fig. 2′.

(Copied from the figures in the 'London Geological Journal,' 1846, Pls. iv and vi.)

3. A portion of the same or a similar jaw, with the crowns of the teeth broken away.

4. Upper or alveolar surface of the same portion of jaw.

5. The crown of one of the teeth from the same portion of jaw.

5*. The base of the same tooth.

5**. Outline of the transverse section near the base of the same tooth.

The above specimens are from the Chalk of Norfolk, or to the North of the Thames; and are in the Collection of Edward Charlesworth, Esq., of York.

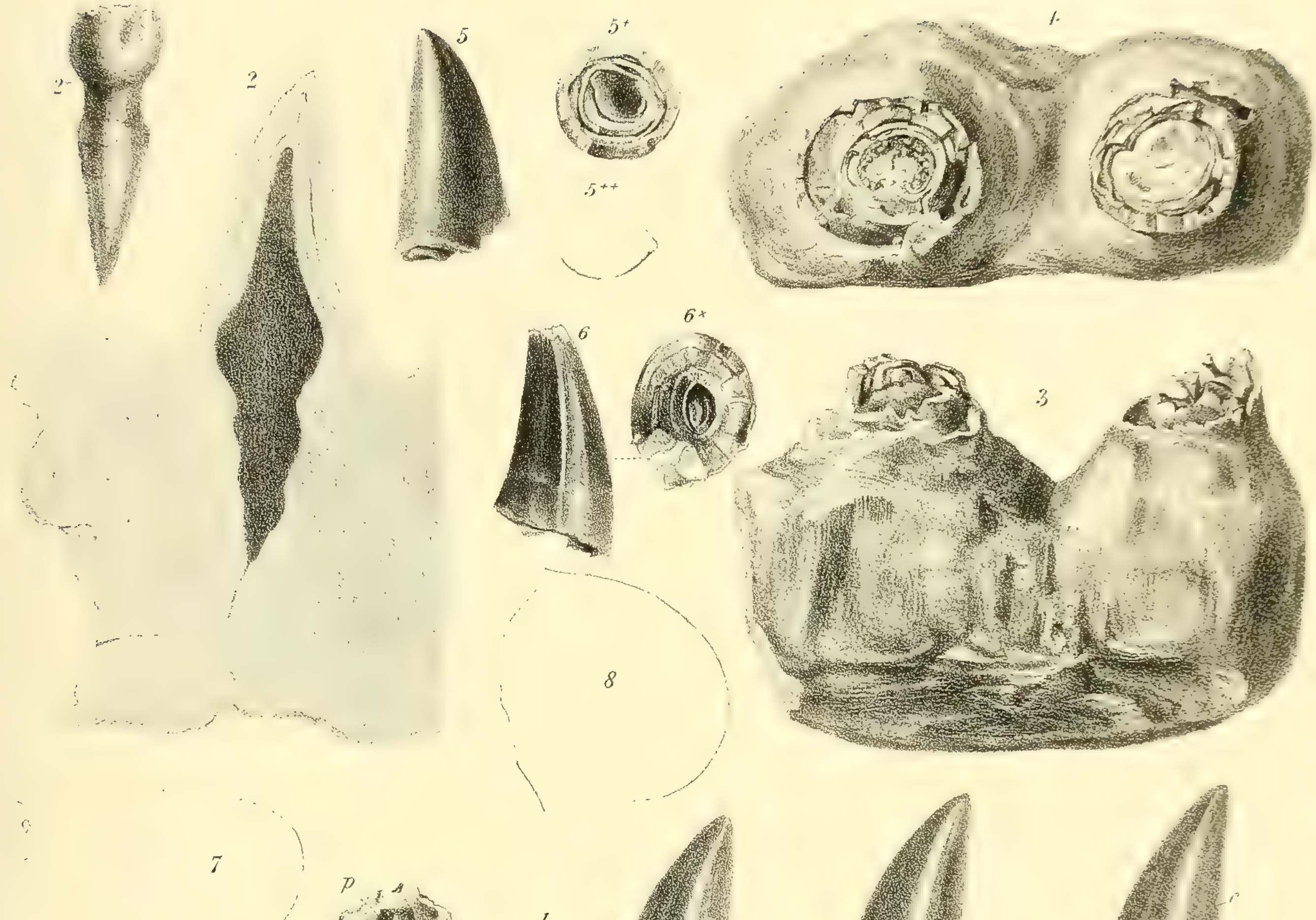
6. The crown of a tooth of *Leiodon anceps*.

From the Chalk of Sussex. In the Collection of Henry Catt, Esq., of Brighton.

7. Outline of the transverse section of a tooth of *Mosasaurus Hoffmanni*.

8. Outline of the transverse section of the tooth of *Mosasaurus Maximiliani*.

9. Outline of the transverse section of the tooth of *Mosasaurus gracilis*.



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TAB. X.

Fig.

1. Mutilated head and vertebræ of the fore-part of the trunk of *Dolichosaurus longicollis.*
2. Outline of part of the lower jaw.
3. The same, magnified.
4. Vertebræ of the hind part of the trunk and pelvis of *Dolichosaurus longicollis.*

    From the Middle Chalk, Kent. Fig. 1, in the Collection of Mrs. Smith, of Tonbridge Wells. Fig. 2, in that of Sir Philip de Malpas Grey Egerton, Bart., F.R.S., M.P.

5. Portion of the lower jaw of *Raphiosaurus subulidens.*
6. Upper or alveolar surface of ditto.

    From the Lower Chalk of Cambridgeshire. In the Collection of James Carter, Esq., of Cambridge.

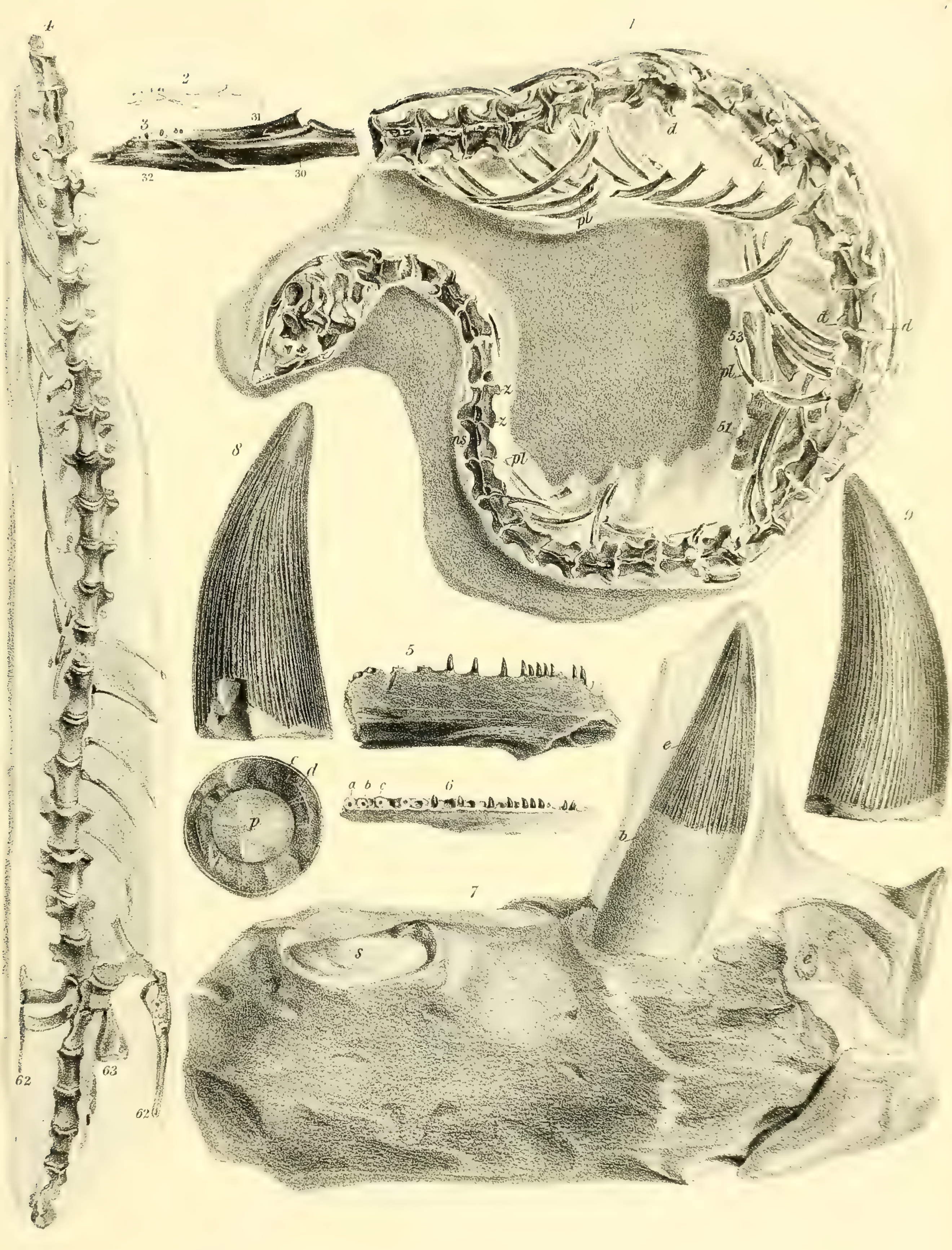
7. Portion of the lower jaw, with a tooth in situ, of *Polyptychodon interruptus.*

    From the Chalk of Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.

8. Crown of the tooth of *Polyptychodon interruptus.*
9. Crown of the tooth of ditto.

From the Green-sand of Cambridgeshire. In the Collection of James Carter, Esq.

All the figures, save fig. 3, are of the natural size.



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TAB. XI.

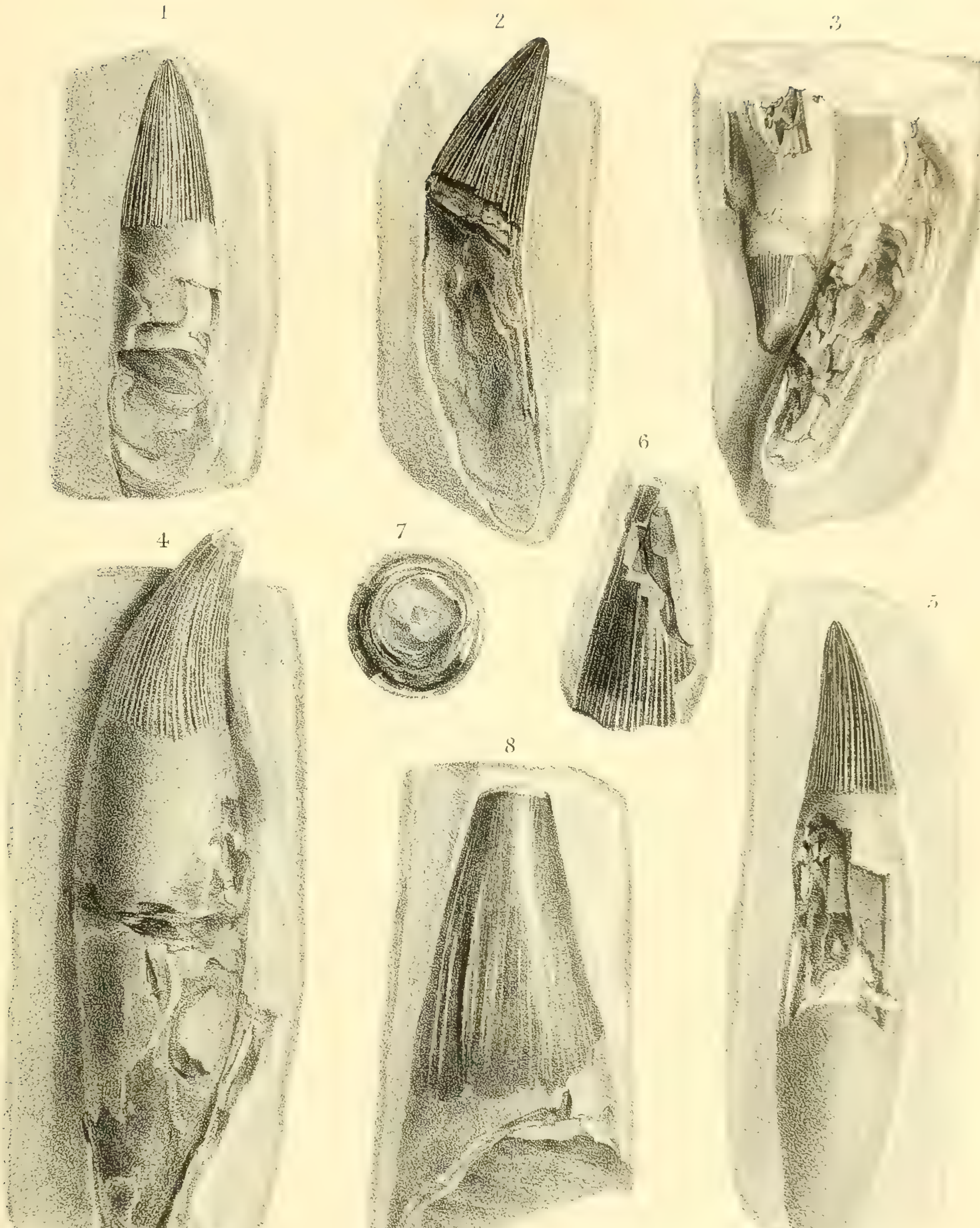
Fig.

1—7. Teeth of *Polyptychodon interruptus,* nat. size.

From the Lower Chalk, near Lewes, Sussex. In the Museum of Mr. Potter, of Lewes.

8. Tooth of *Polyptychodon continuus* (?), nat. size.

From the Lower Chalk of Sussex. In the Museum of Henry Catt, Esq., of Brighton.



Polyptychodon.

From Nature on Stone by J. Erxleben

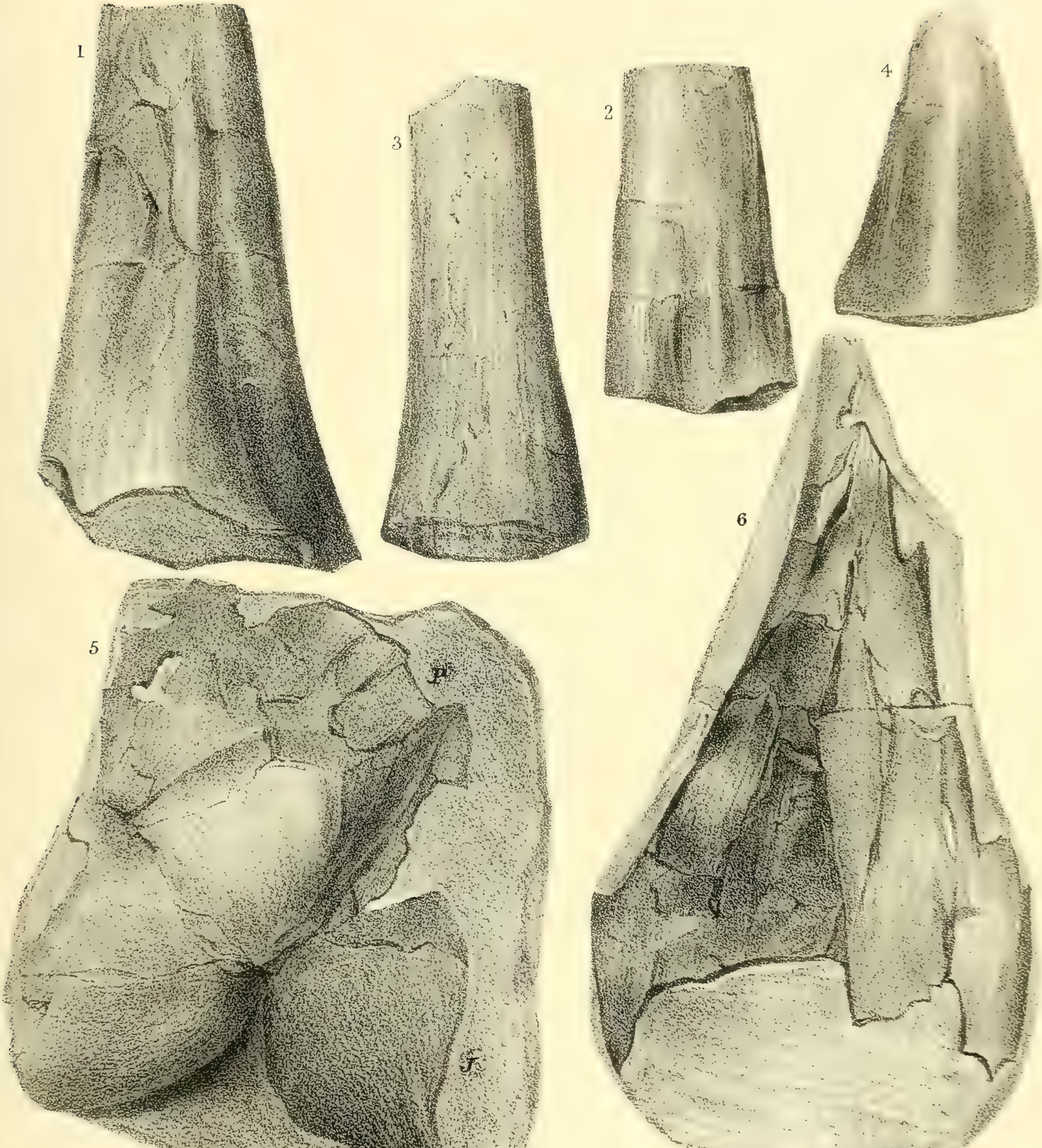
TAB. XII.

Polyptychodon continuus (?).

Fig.

1. Lower end of shaft of femur, (scale of 2 inches to 1 foot.)
2. Lower end of shaft of humerus, (scale of 2 inches to 1 foot.)
3. A larger portion of the shaft of a long bone, (scale of 2 inches to 1 foot.)
4. A fragment of a long bone, near the proximal end of humerus?
5. Portions of the pubis, P, and ischium, I, (scale of 2 inches to 1 foot.)
6. Fractured portion of the ilium, (scale of 4 inches to a foot.)

From the Green-sand, near Hythe. Discovered and presented by H. Mackeson, Esq., of Hythe, Kent, to the British Museum.



J. Erxleben. del et lith.

Polyptychodon (?)

TAB. XIII.

Polyptychodon continuus (?).

Fig.

1. A block of Green-sand stone, containing the shaft of a tibia, T, and the lower end of that of a fibula, F, (scale of 2 inches to a foot.)

2. A block of Green-sand stone, containing the shaft of the humerus, H, and that of the ulna, U, (same scale.)

3. A portion of the matrix, with impressions of the shafts of two metacarpal or metatarsal bones (same scale.)

4 and 5. Fragments of long bones (same scale.)

From the Green-sand, near Hythe, Kent. Discovered and presented by H. Mackeson, Esq., to the British Museum.

Polyptychodon(?)

TAB. XIV.

Fig.

1 and 2. Crown of the tooth of *Polyptychodon interruptus.*

3. Outline of the base of the same tooth.

From the Chalk of Sussex.

4. Crown of the tooth of *Polyptychodon continuus.*

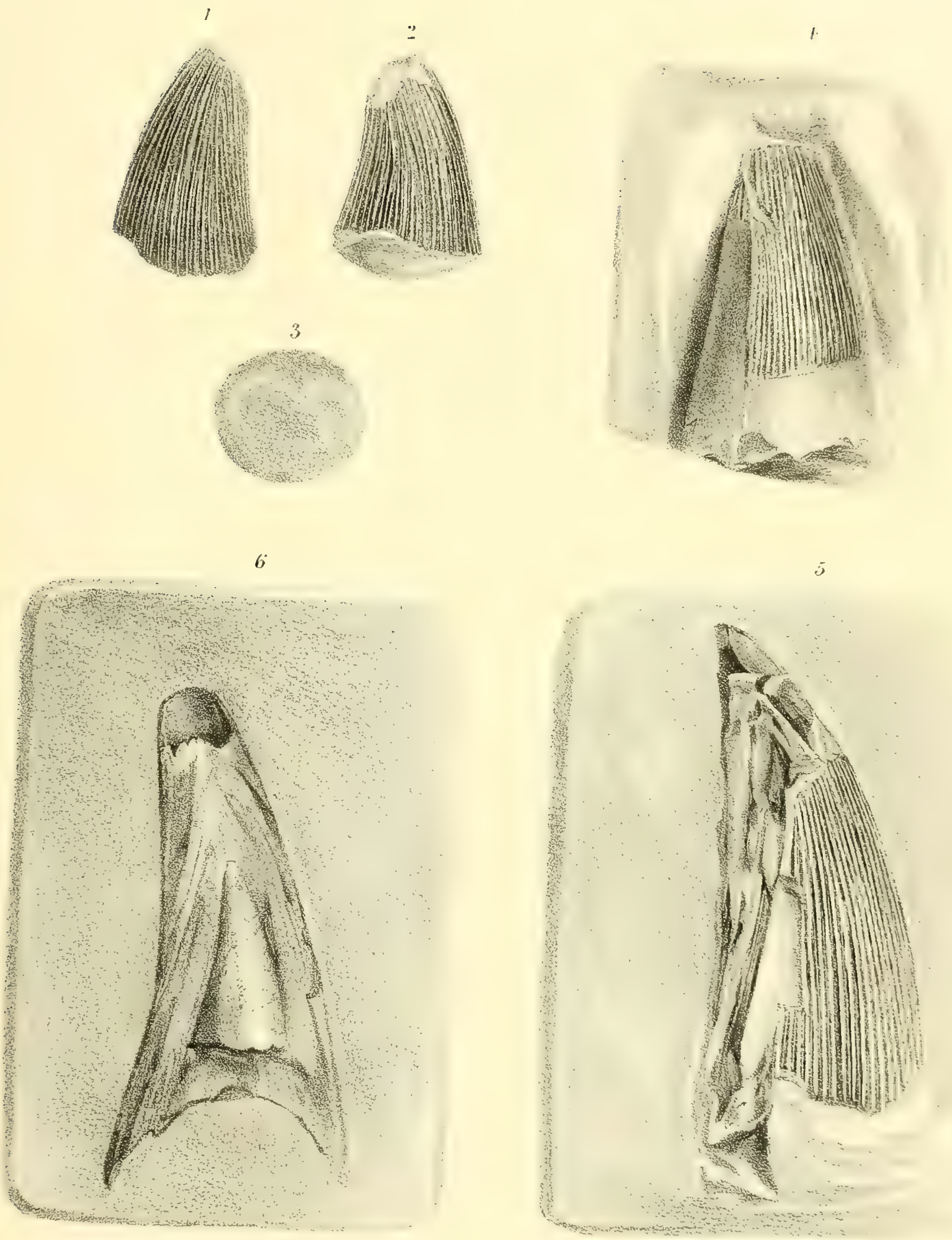
From the Chalk of Kent. In the Collection of H. W. Taylor, Esq., of Brixton Hill.

5. Crown of the tooth of *Polyptychodon continuus.*

6. Longitudinal section of the same tooth.

From the Kentish Rag, Green-sand Formation, near Maidstone. In the Collection of J. Bensted, Esq.

All the figures are of the natural size.



stone by J. Erxleben

TAB. XV.

A slab of Green-sand, with portions of the skeleton of a young Crocodile.

From near Hastings. In the Collection of W. D. Saull, Esq., F.G.S.

Figs. 1 and 2. Portions of the jaws of the same Crocodile, nat. size.

T. XV.

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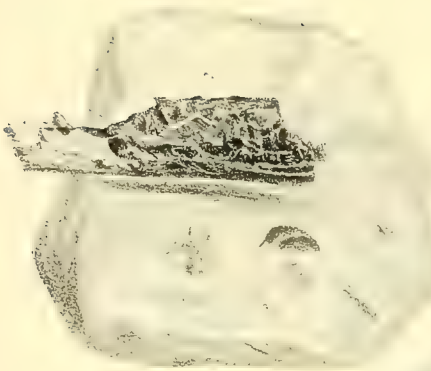

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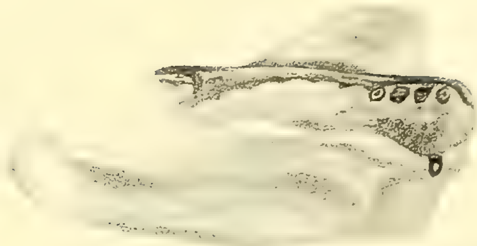

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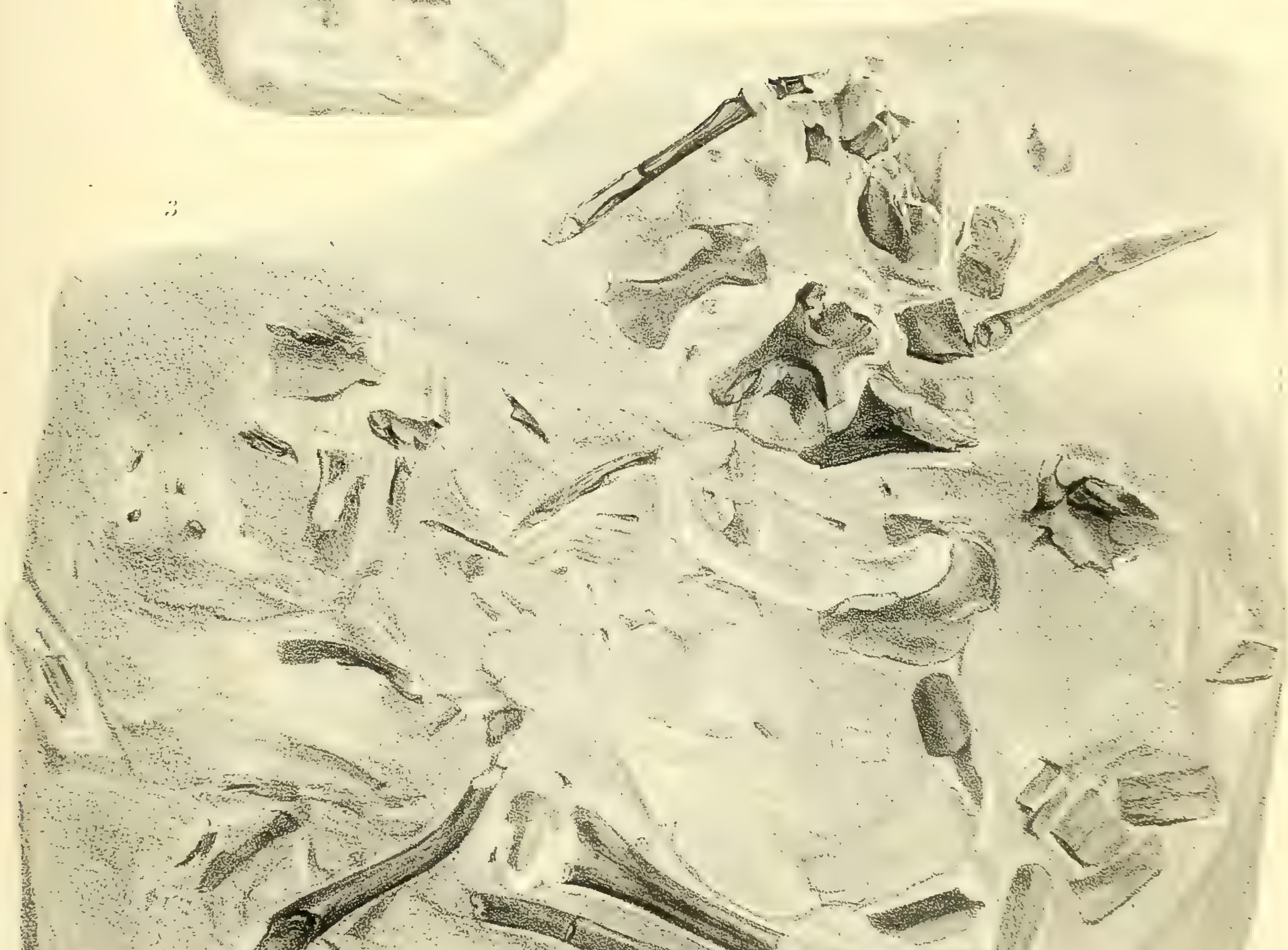

rom Nature on stone by rxleben

TAB. XVI.

A portion of the lower jaw of *Polyptychodon.*

From the Chalk of Kent. In the Collection of J. Toulmin Smith, Esq., of Highgate. Nat. size.

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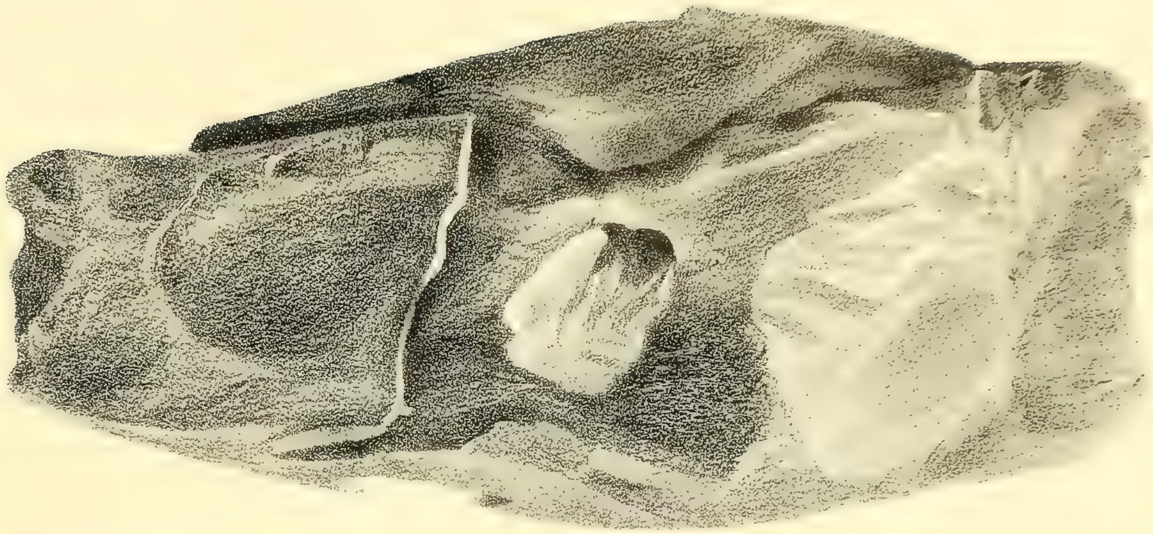

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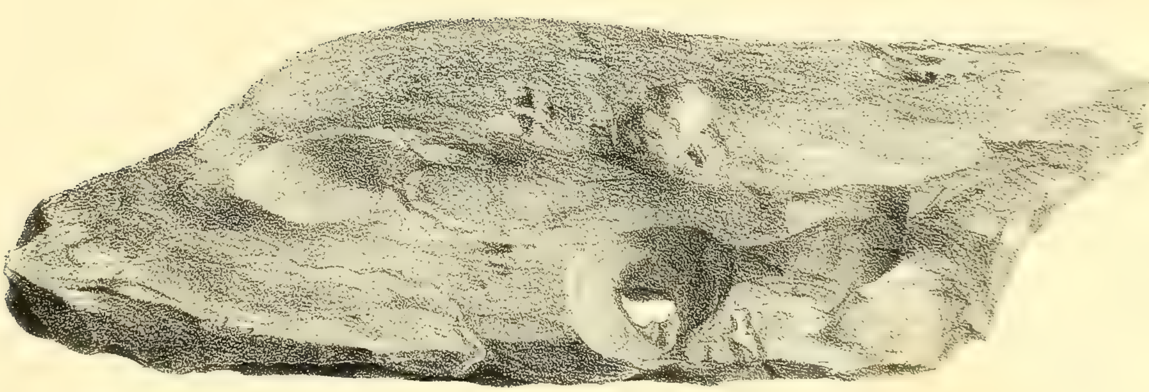

J. Erxleben del. et lith.

TAB. XVII.

Portion of the paddle of a large *Plesiosaurus*, nat. size.

From the Chalk of Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.


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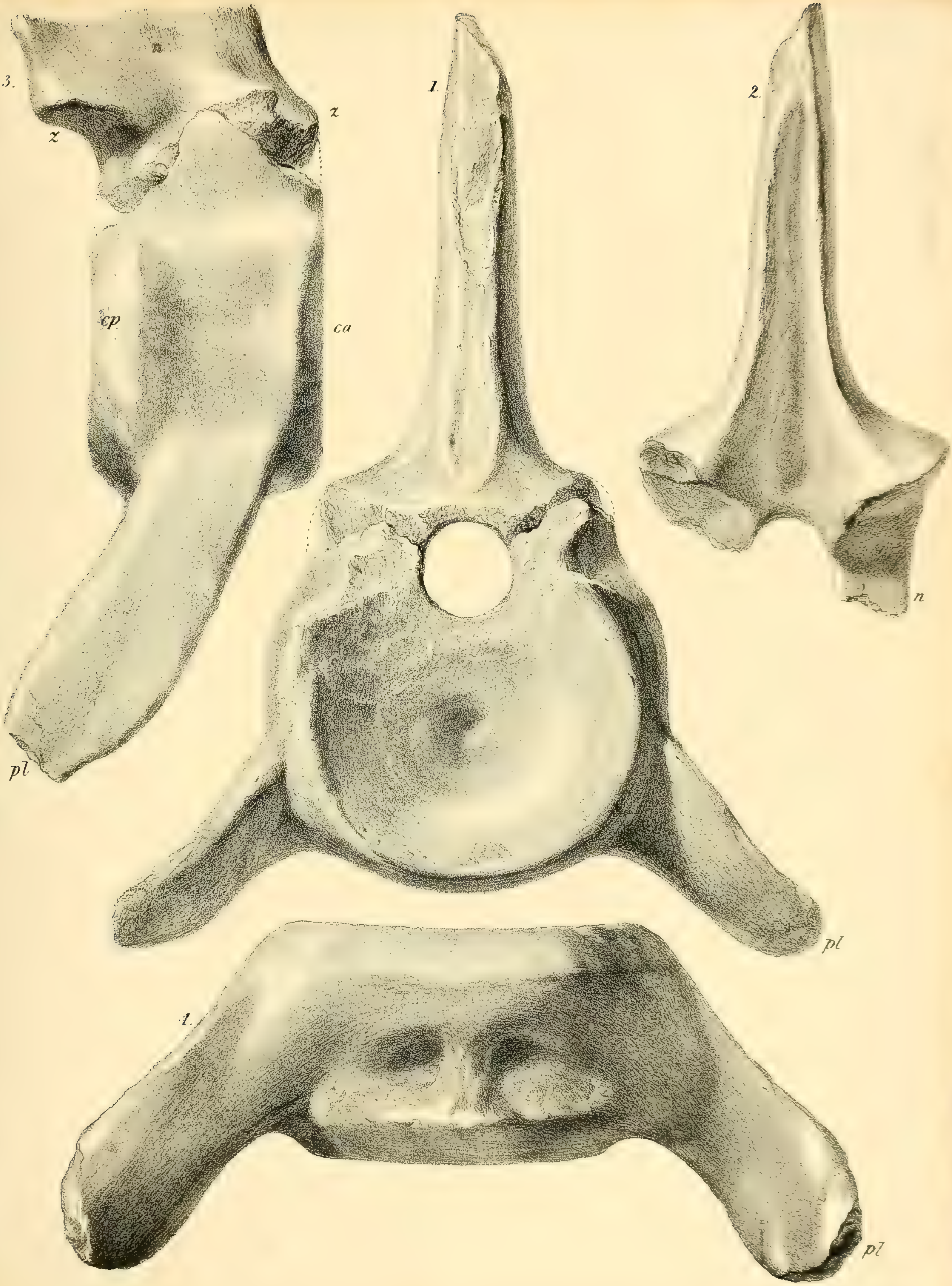
TAB. XVIII.

Cervical Vertebra of *Plesiosaurus Bernardi*, nat. size.

Fig.
1. Front view.
2. Back view of spinous process.
3. Side view.
4. Under view.

From the Upper Chalk of Sussex. In the Collection of the late Fred. Dixon, Esq., F.G.S., of Worthing.



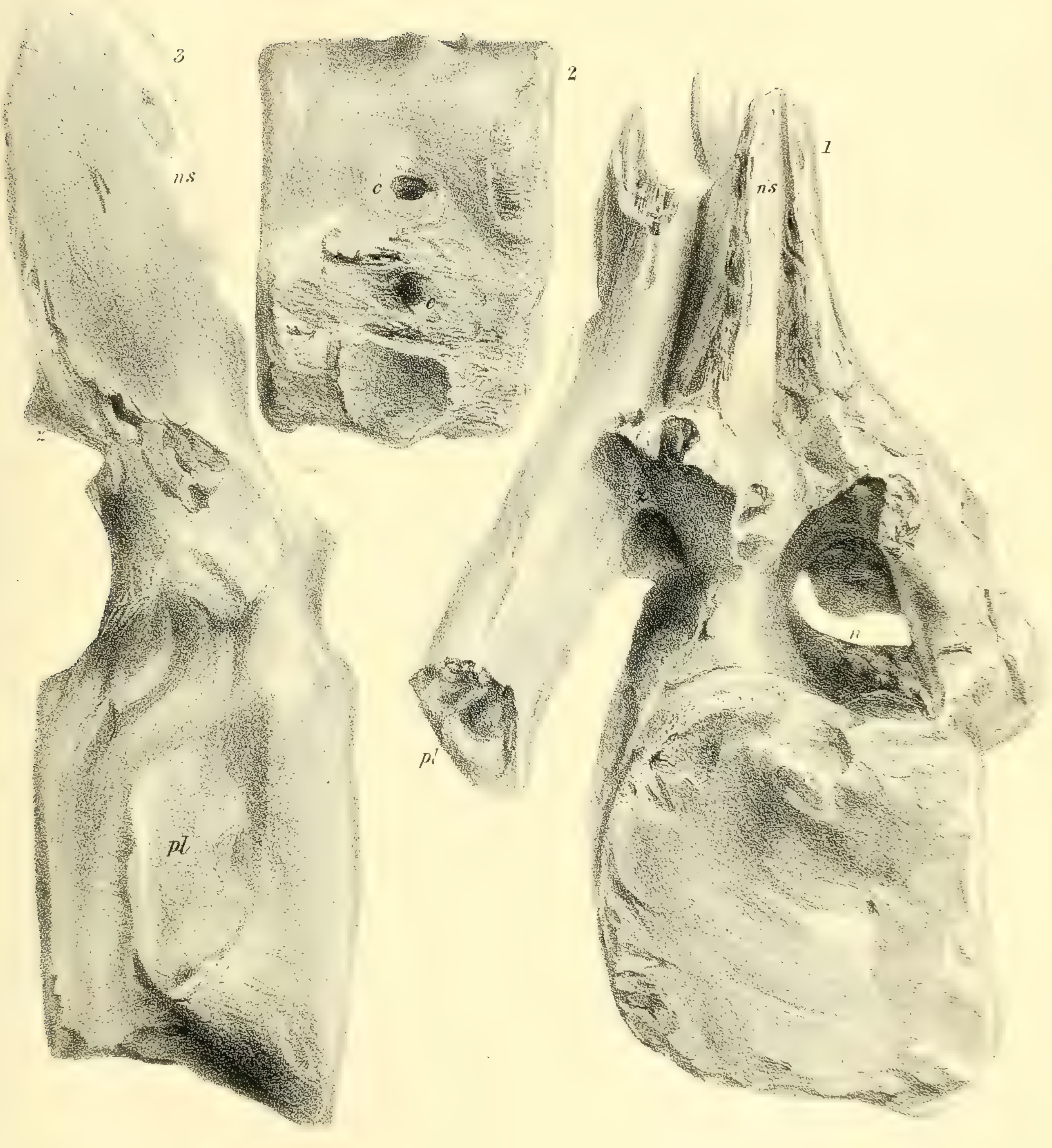
Lith. from Nature by G. Scharf

TAB. XIX.

Cervical vertebra of another species of *Plesiosaurus*.

From the Chalk of Kent. In the Collection of Mrs. Smith, of Tonbridge Wells.

T. XIX



From Nature on Stone by T. Erxleben.

TAB. XX.

Plesiosaurus pachyomus, nat. size.

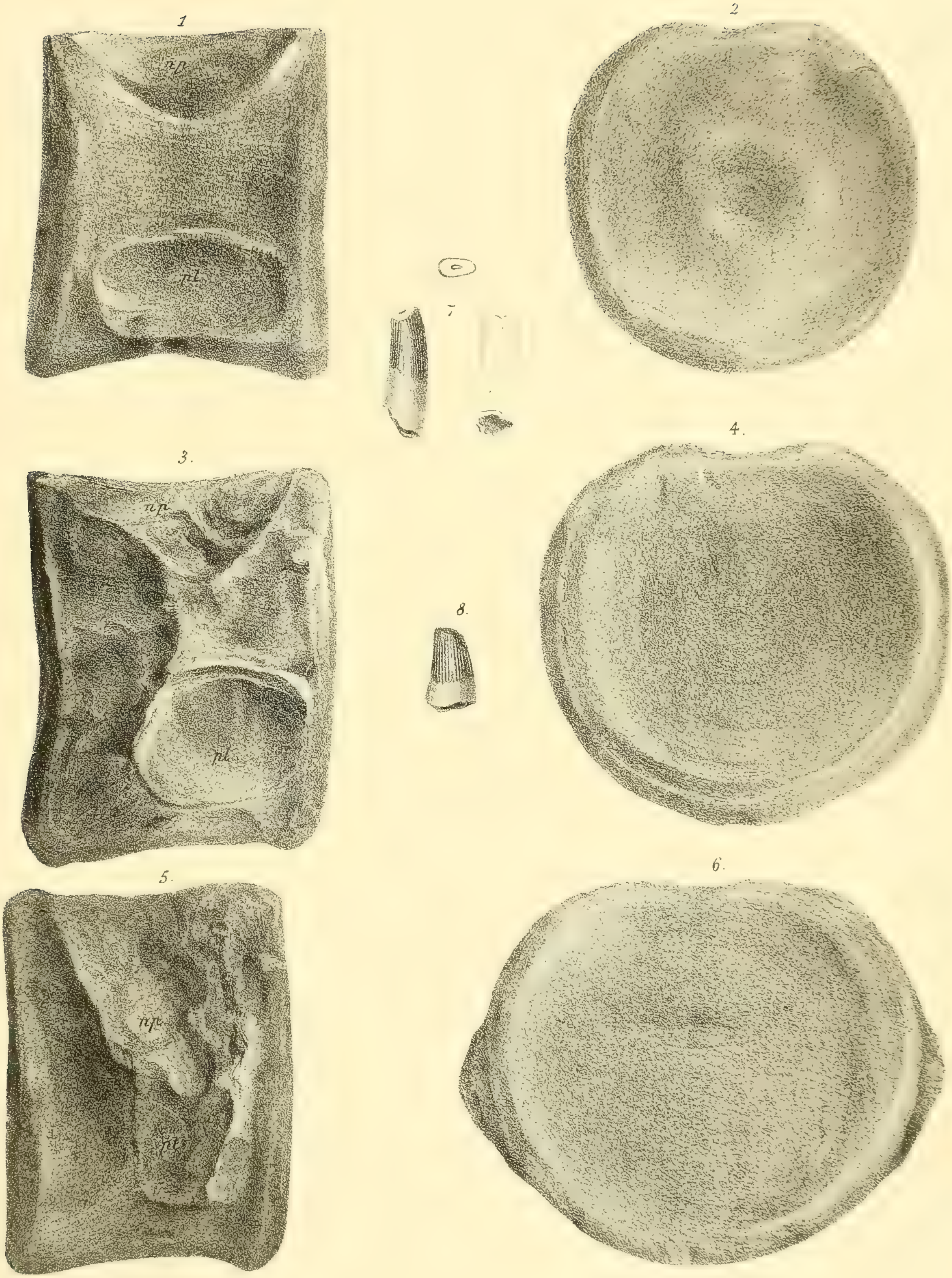
Fig.

1. Side view of centrum of cervical vertebra.
2. Front view of ditto.
3. Side of centrum of a more posterior cervical vertebra.
4. Front view of ditto.
5. Side view of centrum of penultimate cervical vertebra.
6. Front view of ditto.

From the Green-sand, near Cambridge. In the Collection of James Carter, Esq., M.R.C.S.

7. Three views of part of a tooth of a Plesiosaurus.
8. Portion of a similar tooth.

From the Green-sand, near Shanklin, Isle of Wight.



From Nature on Stone by J. Erxleben

TAB. XXI.

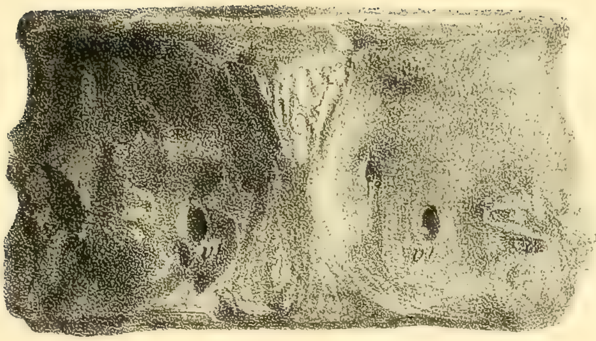
Plesiosaurus pachyomus, nat. size.

Fig.

1. Side view of centrum of dorsal vertebra.
2. Under view of ditto.
3. Upper view of ditto.
4. Upper view of the centrum of a smaller dorsal vertebra.
5. A section through the centrum of a small dorsal vertebra, showing the course of the vertical venous canals.
6. Under view of a caudal vertebra.

From the Green-sand, near Cambridge. In the Collection of James Carter, Esq., M.R.C.S.

2.



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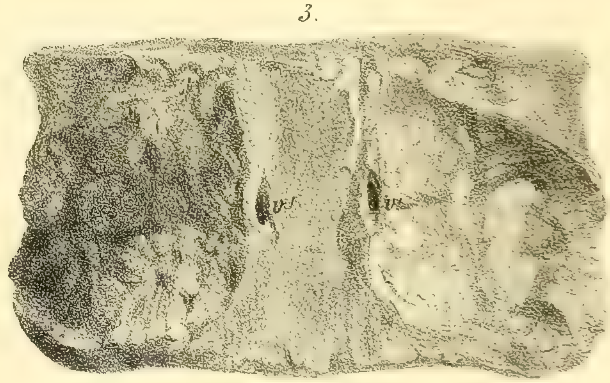

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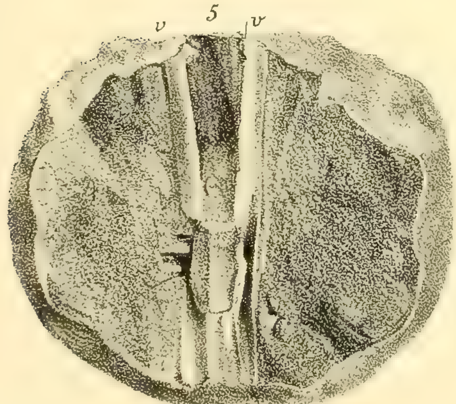

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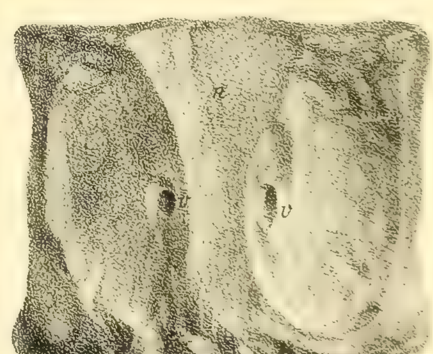


del. et lith.

Day & Son Lith^rs to The Queen

TAB. XXII.

Ichthyosaurus campylodon, nat. size.

Fig.

1. Side view of the body or centrum of a vertebra of the trunk.

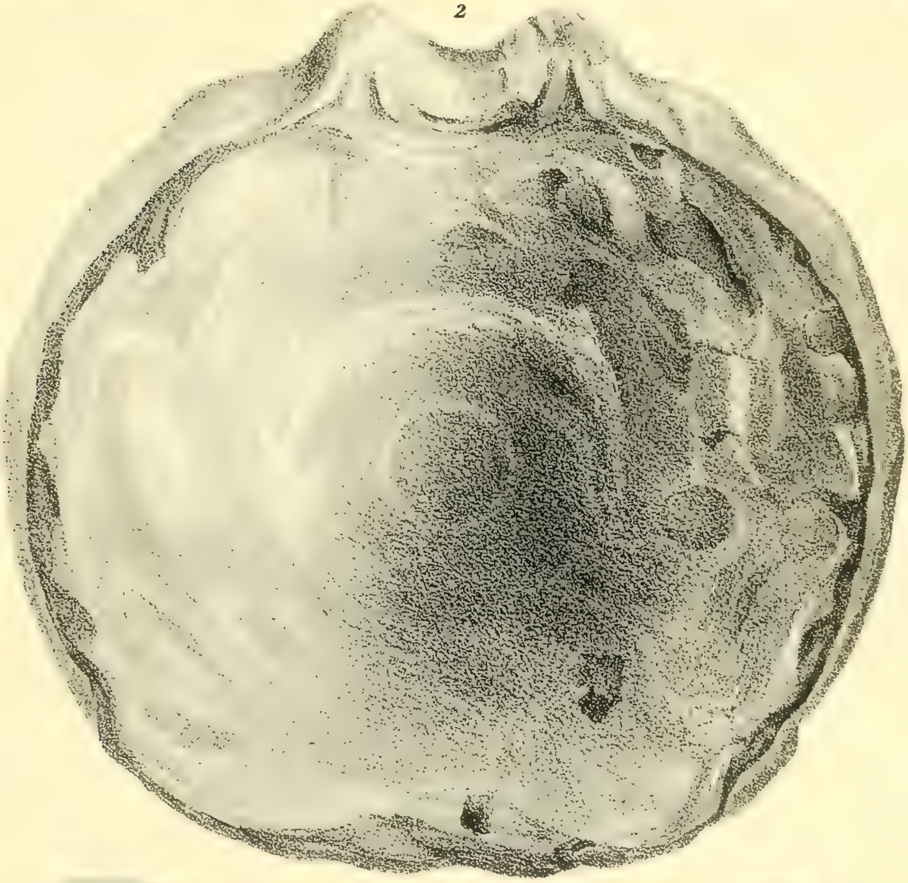
2. Front view of ditto.

3. Section of a similar vertebra, showing the form and depth of the opposite articular surfaces.

From the Grey-chalk of the Round-down Tunnel, near Dover. In the Collection of H. W. Taylor, Esq., of Brixton Hill.

1

2



3

xleben del. et lith.

TAB. XXIII.

Ichthyosaurus campylodon, nat. size.

Fig.

1. Outer side of the dentary bone of the lower jaw.

1*. Form of the section of the fractured end.

2. Inner side of a portion of the right ramus of the same lower jaw, formed by the dentary piece, 32, with the terminations of the splenial pieces, 31.

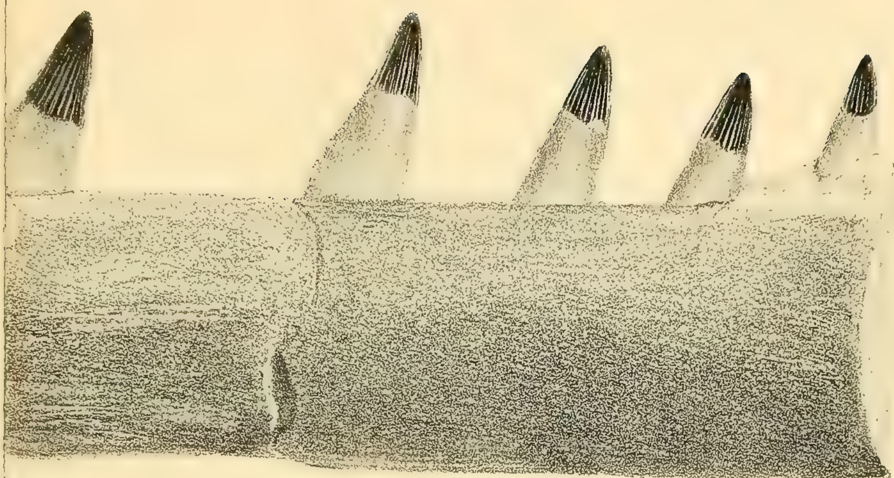
2*. Form of the section of the hinder fractured end.

2**. Form of the section of the fore-part of the same portion.

3. Fragment of a portion of the right premandibular bone.

4. One of the teeth, from the base of which part of the thick cement has been removed.

From the Grey-chalk of the Round-down Tunnel, near Dover. In the Collection of H. W. Taylor, Esq., of Brixton Hill.



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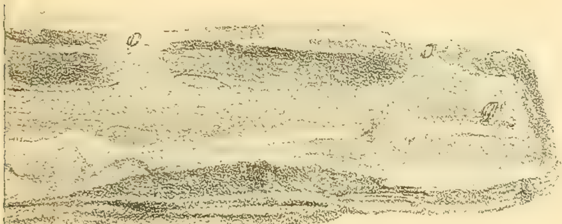

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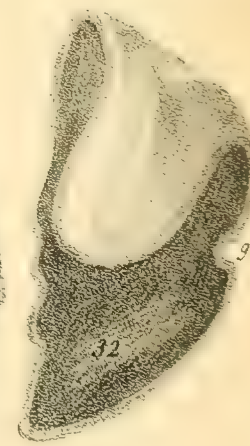
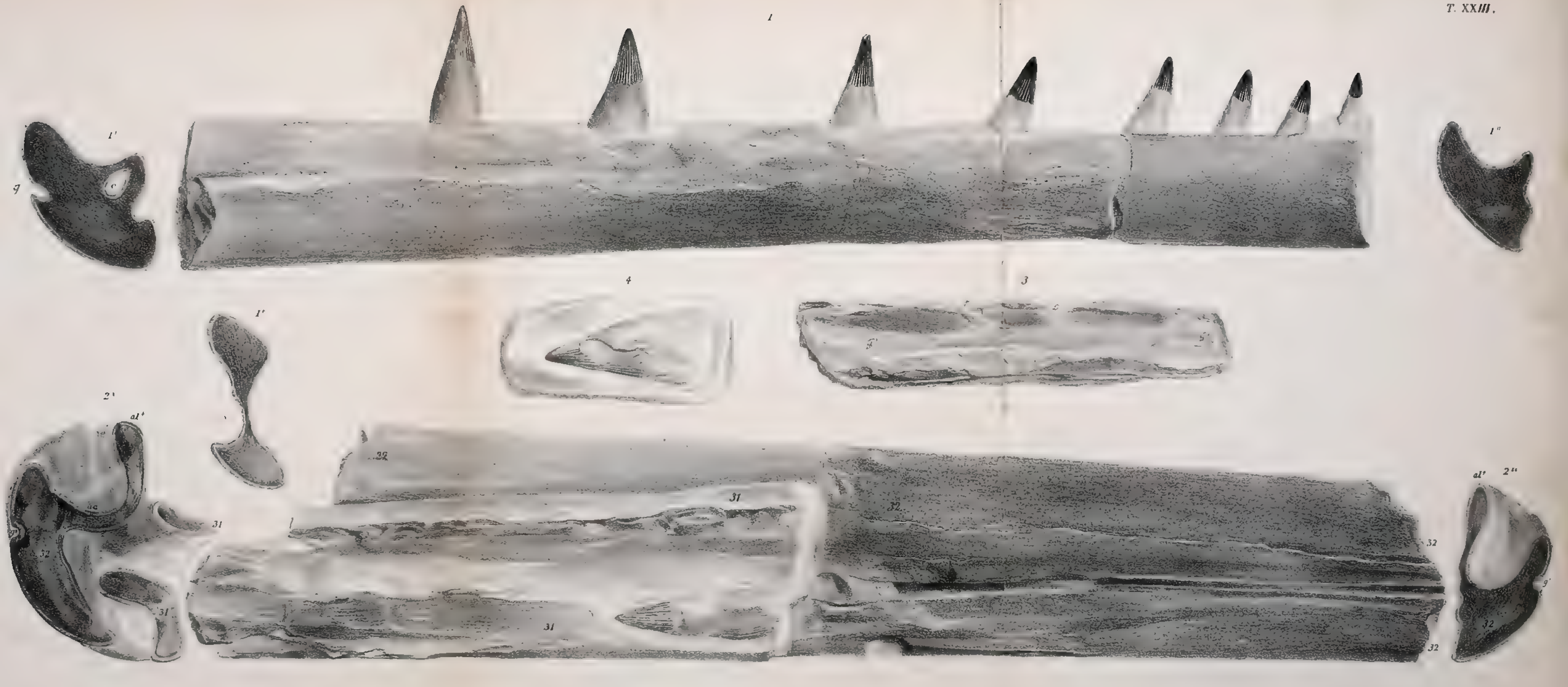


Day & Son Lithrs to The Queen



Erxleben del et lith

Day & Son, Lith^rs to The Queen

TAB. XXIV.

Pterodactylus compressirostris, nat. size.

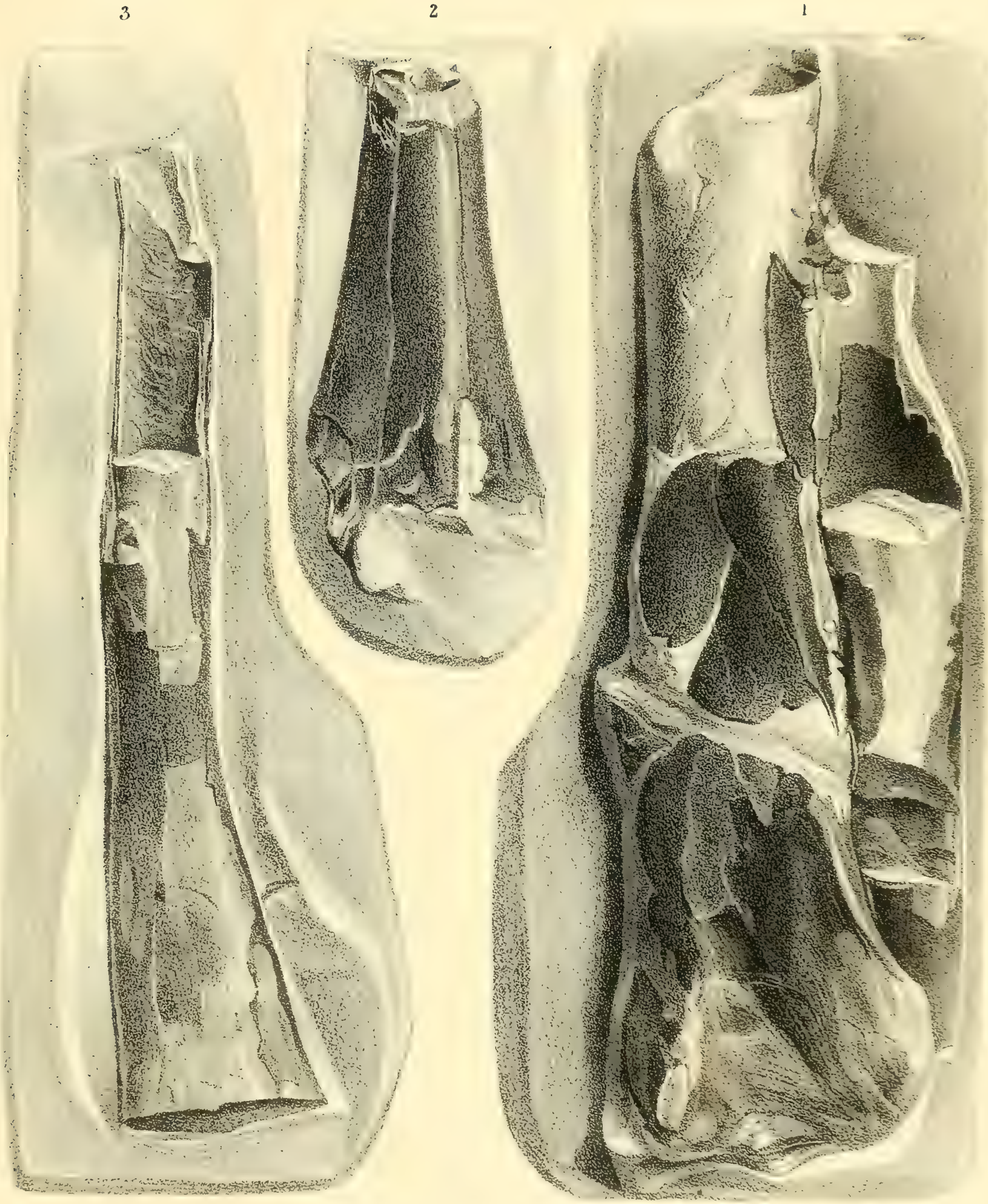
Fig.

1. The lower or distal half of the humerus, with a portion of the radius or ulna.

2. One end of a long bone of the wing of the same Pterodactyle.

3. Part of the shaft of the radius or ulna, from the same block of Chalk, as fig. 1.

From the Chalk of Kent. In the Collection of Thomas Charles, Esq., of Maidstone.


3
2
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TAB. XXV.

Ichthyosaurus campylodon, nat. size.

Fig.

1. Side view of a portion of the skull.

2. Upper view of the hinder half of the same portion of skull, showing the extremity of the nasal bones, 15, dipping under the premaxillaries, 22.

From the Lower Chalk, near Cambridge. In the Collection of James Carter, Esq., M.R.C.S.


g
g'

From Nature on Stone by J Erxleben

TAB. XXVI.

Ichthyosaurus campylodon, nat. size.

Fig.

1. Section of the skull anterior to the maxillary bones.

    15. Nasal bones.

    22. Premaxillaries: *g*, external groove; *al*, origin of the internal alveolar plate; *al'*, where it appears to have been broken; *al''*, thickened terminal border of the plate; *a*, external alveolar wall.

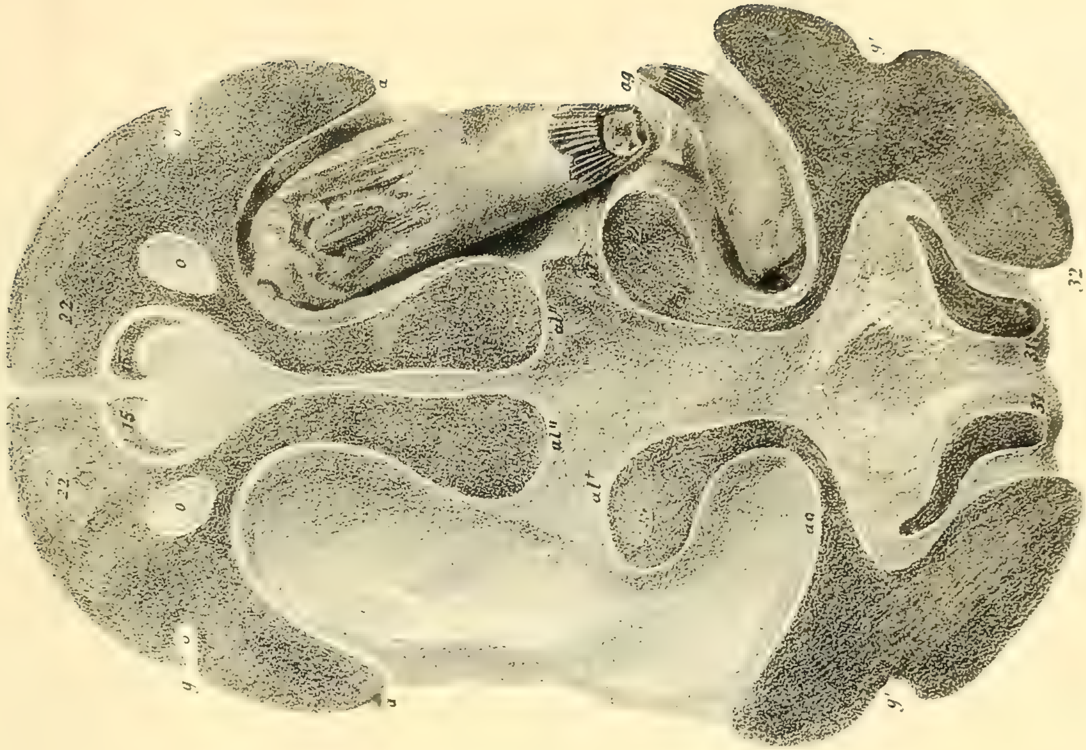
    31. Splenial part of lower jaw.

    32. Dentary part of ditto: *g'*, external groove; *al**, internal alveolar wall.

2. Section of the skull near the termination of the nasal bones 15, 15. *o*, vascular canal: the other letters and figures as in the foregoing figure.

From the lower Chalk of Cambridgeshire. In the Collection of James Carter, Esq., M.R.C.S.

2



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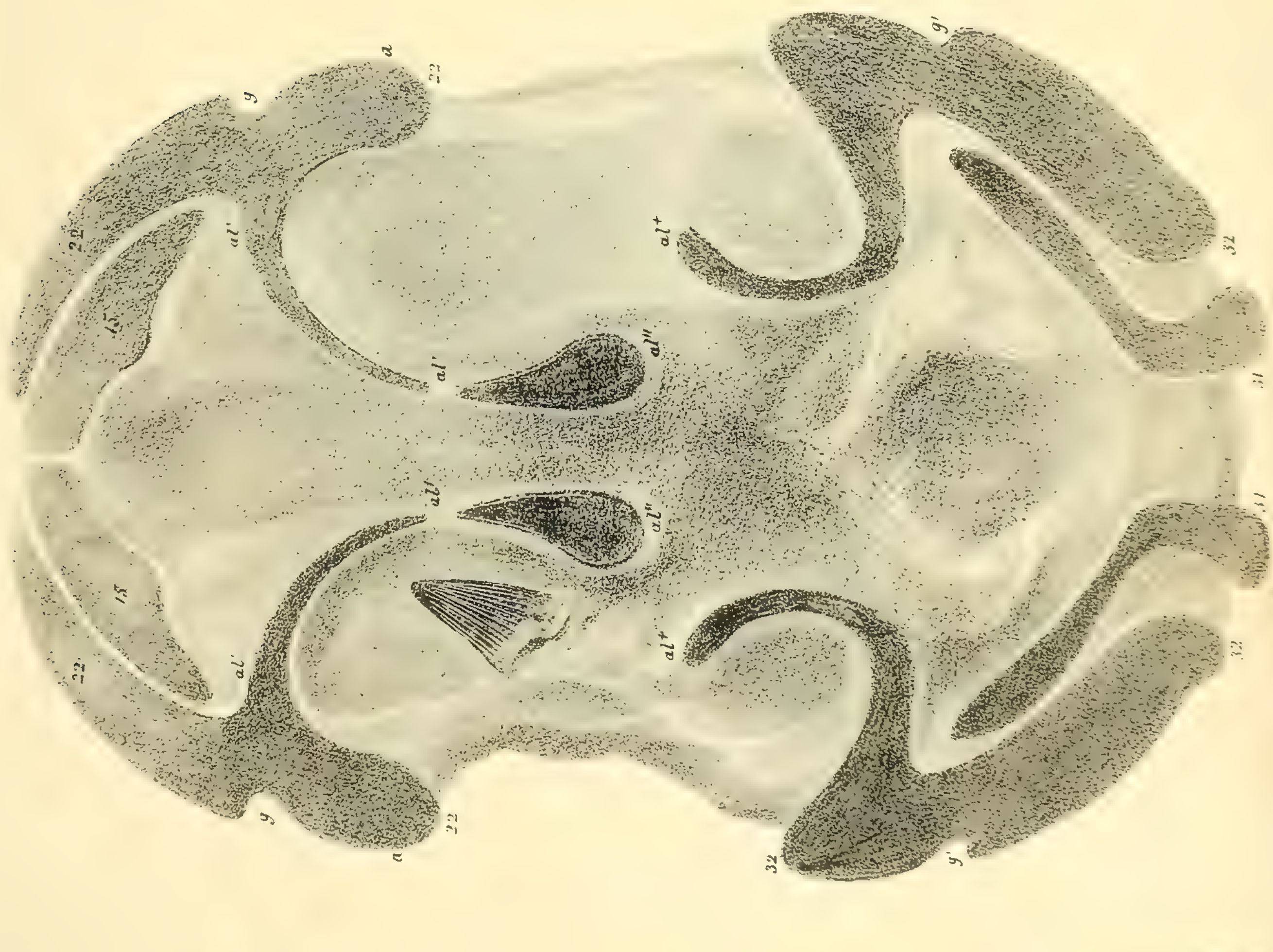


From Nature on Stone by T. Erxleben

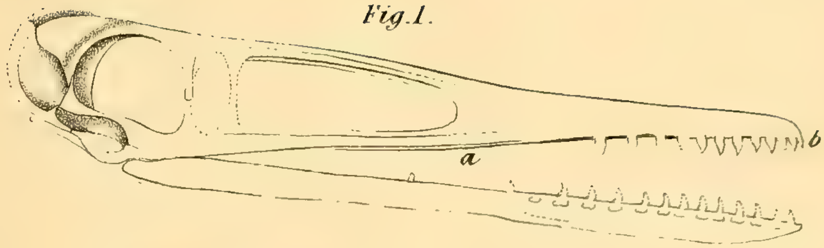
TAB. XXVII.

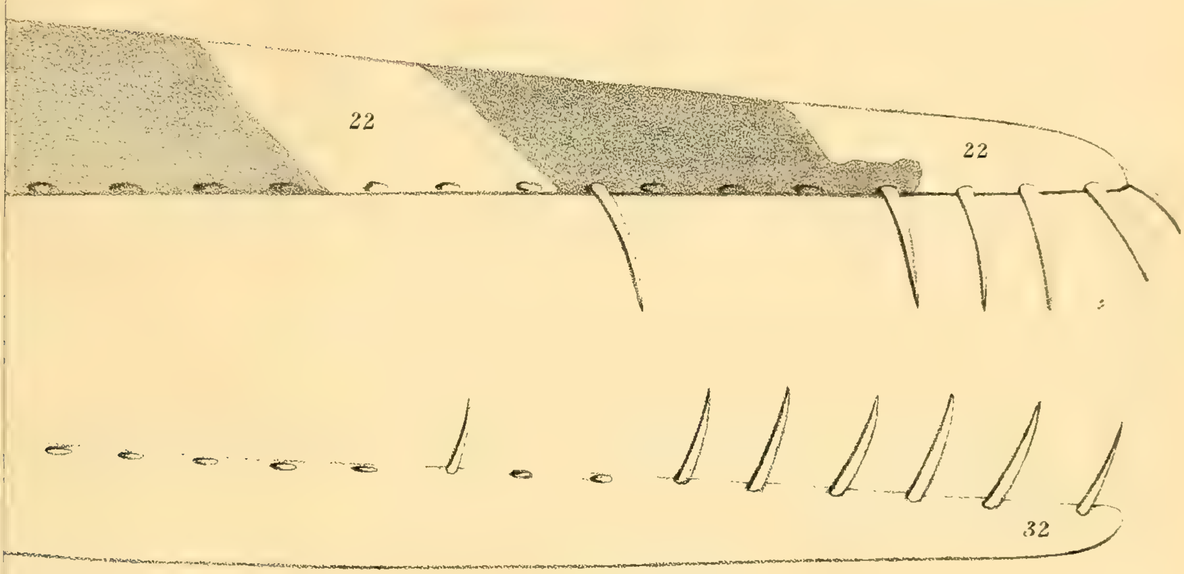
Fig.

1. Skull of *Pterodactylus longirostris* (after Collini).
2. Left side of the skull of *Pterodactylus crassirostris.*
3. Right side of the same skull.
4. Restoration of the same skull (after Goldfuss).
5. Restoration of the skull of *Pterodactylus compressirostris.*

The tinted portions of fig. 5 are from the Middle Chalk of Kent, and are in the Museum of James Scott Bowerbank, Esq., F.R.S.

Fig. 1.





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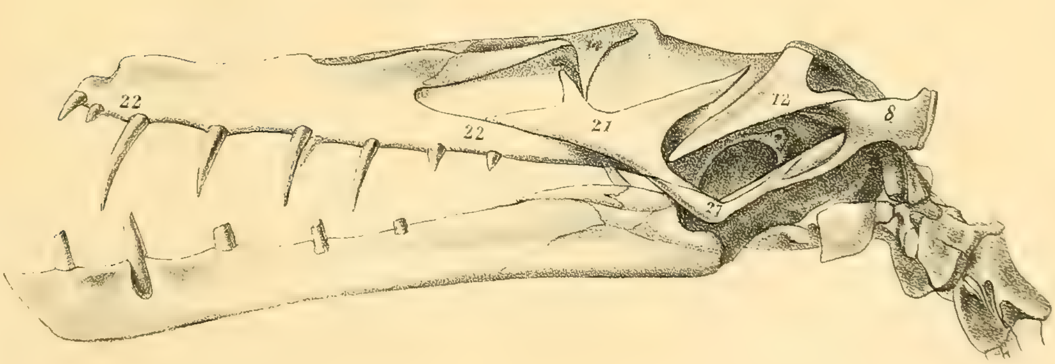
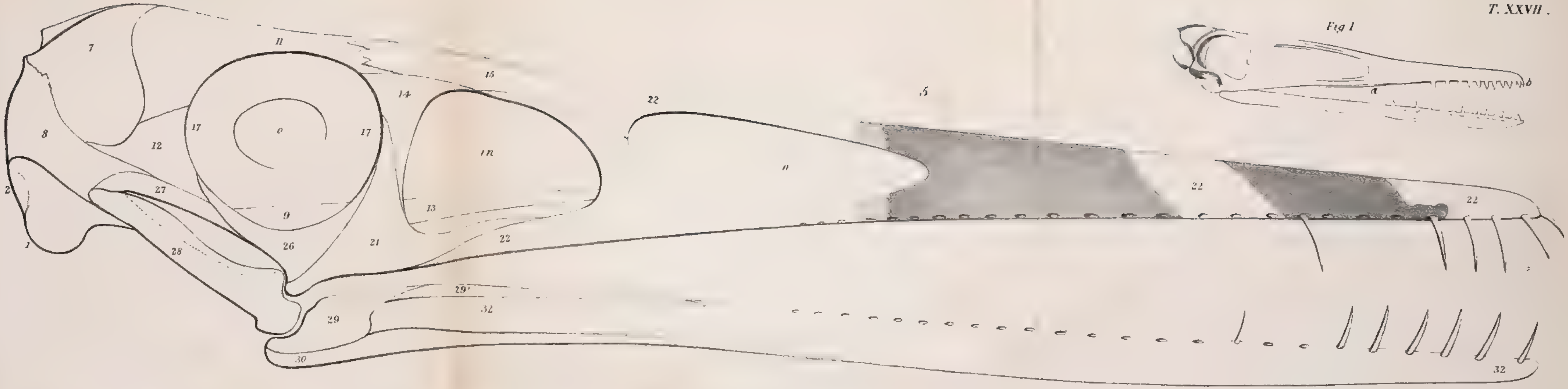


Day & Son. Lith^rs to The Queen

T. XXVII.

Fig 1

5



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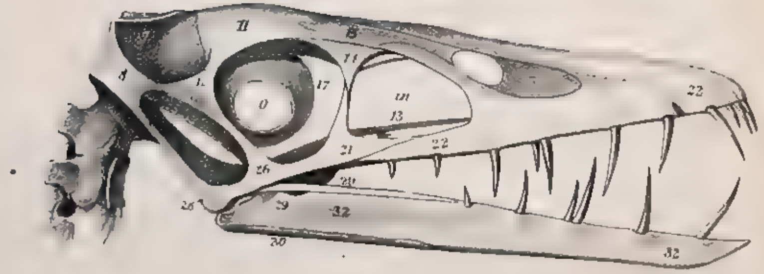

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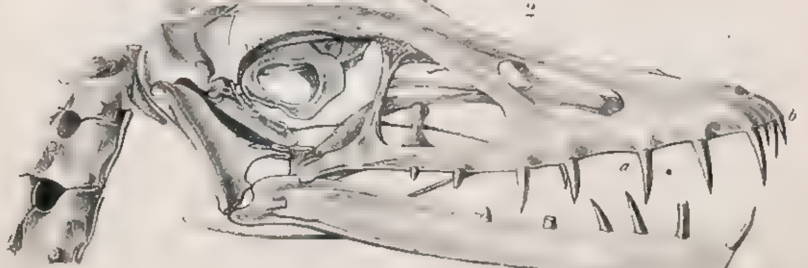

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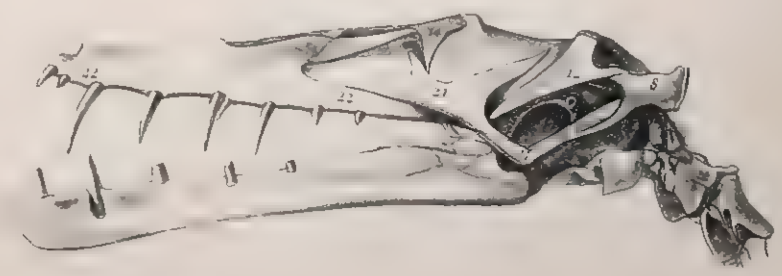


J. Dinkel lith

Day & Son, Lithrs to The Queen

TAB. XXVIII.

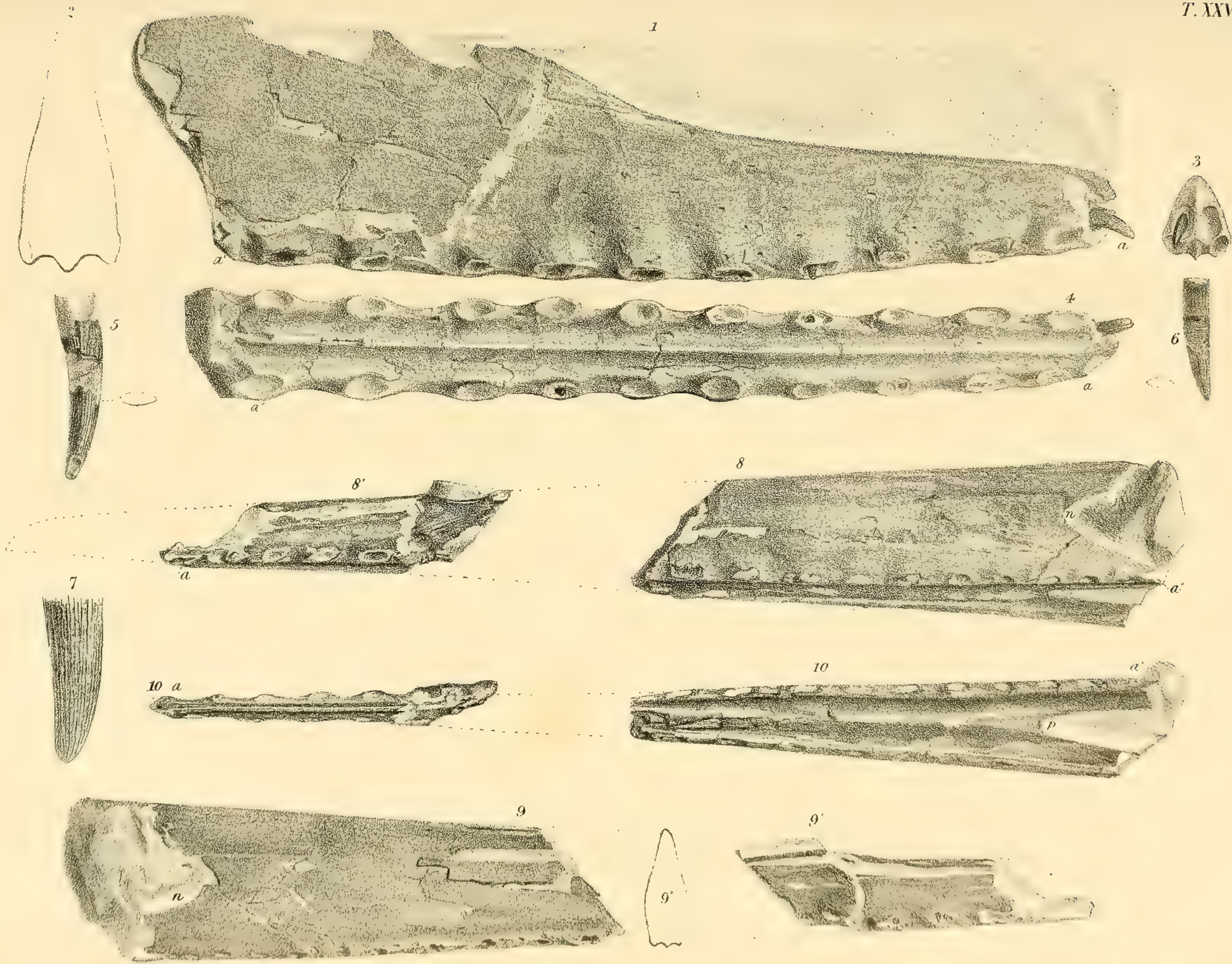
Fig.

1. Side view of the end of the upper jaw of *Pterodactylus Cuvieri,* nat. size ; *a, a,* the alveoli.
2. Outline of the section at the hinder fractured part.
3. Anterior end of the jaw.
4. Palatal surface of the jaw.
5. The crown of one of the teeth of the same jaw.
6. The crown of another tooth of the same jaw.
7. Magnified view of a portion of the crown of a tooth of the same jaw.
8. Left side of two portions of the upper jaw of *Pterodactylus compressirostris,* nat. size ; *a, a,* alveoli.
9. Right side of the same two portions of jaw.

9*. Transverse section of the jaw at the fore part of the hinder fragment.

10. Palatal surface of the same two portions of jaw ; *p,* the naso-palatine aperture.

Both the foregoing specimens are from the Burham Chalk-pit, Kent ; and are in the Cabinet of James S. Bowerbank, Esq., F.R.S.



I. Dunker. del. et lith.

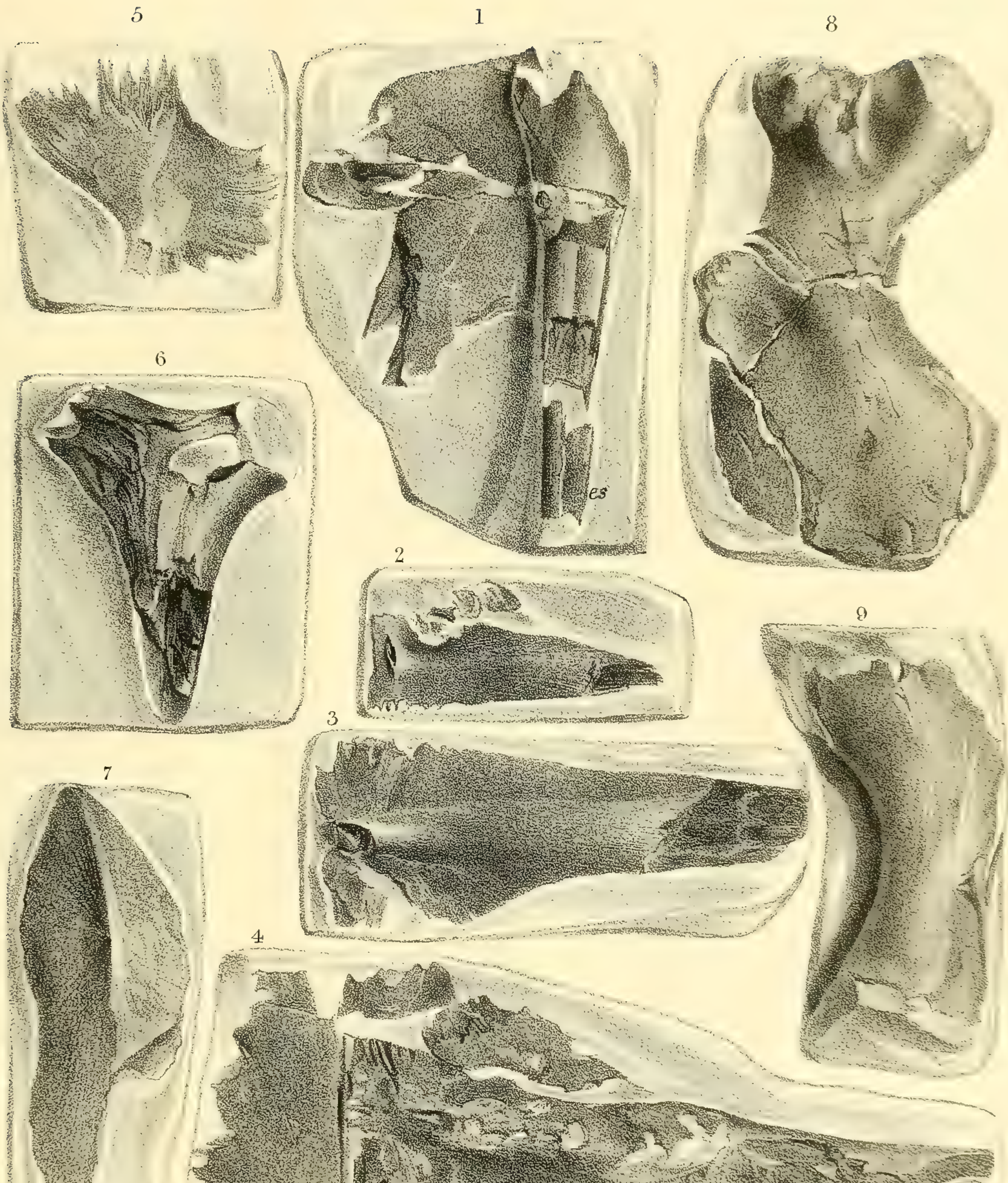
TAB. XXIX.

Chelonian Fossils, nat. size.

Fig.

1. Part of the plastron of a Turtle: the episternum, *es*, resting upon the left hyosternal.
2. Part of a rib of a carapace.
3. Part of a larger rib of the carapace.
4. Part of a rib of a carapace.
5. The hyosternal element of the plastron of a *Chelone Benstedi*.
6. Portion of the scapula and clavicle of a Turtle.
7. One of the marginal plates of the carapace.
8. A humerus of a Turtle.
9. An ulna of a Turtle.

From the Chalk of Kent. In the Museum of Thomas Charles, Esq., of Maidstone.



From Nature on Stone by J. Erxleben.

TAB. XXX.

Fig.

1 and 2. Wing-bone of *Pterodactylus Cuvieri.*

2*. Articular end of ditto: *a* and *b*, articular surfaces; *c*, fractured surface leading to the cavity of the bone.

3. Portion of the narrowest side of the same bone, showing the pneumatic foramen at *p*.

3*. Section of the same bone four inches from the articular end, showing the thickness of its dense osseous wall, and the wide air-cavity.

From the Burham Chalk-pit, Kent. In the Collection of J. Toulmin Smith, Esq.

4. A similar portion of a corresponding wing-bone of *Pterodactylus compressirostris*, nat. size: *p*, the pneumatic foramen.

4*. Part of the articular extremity.

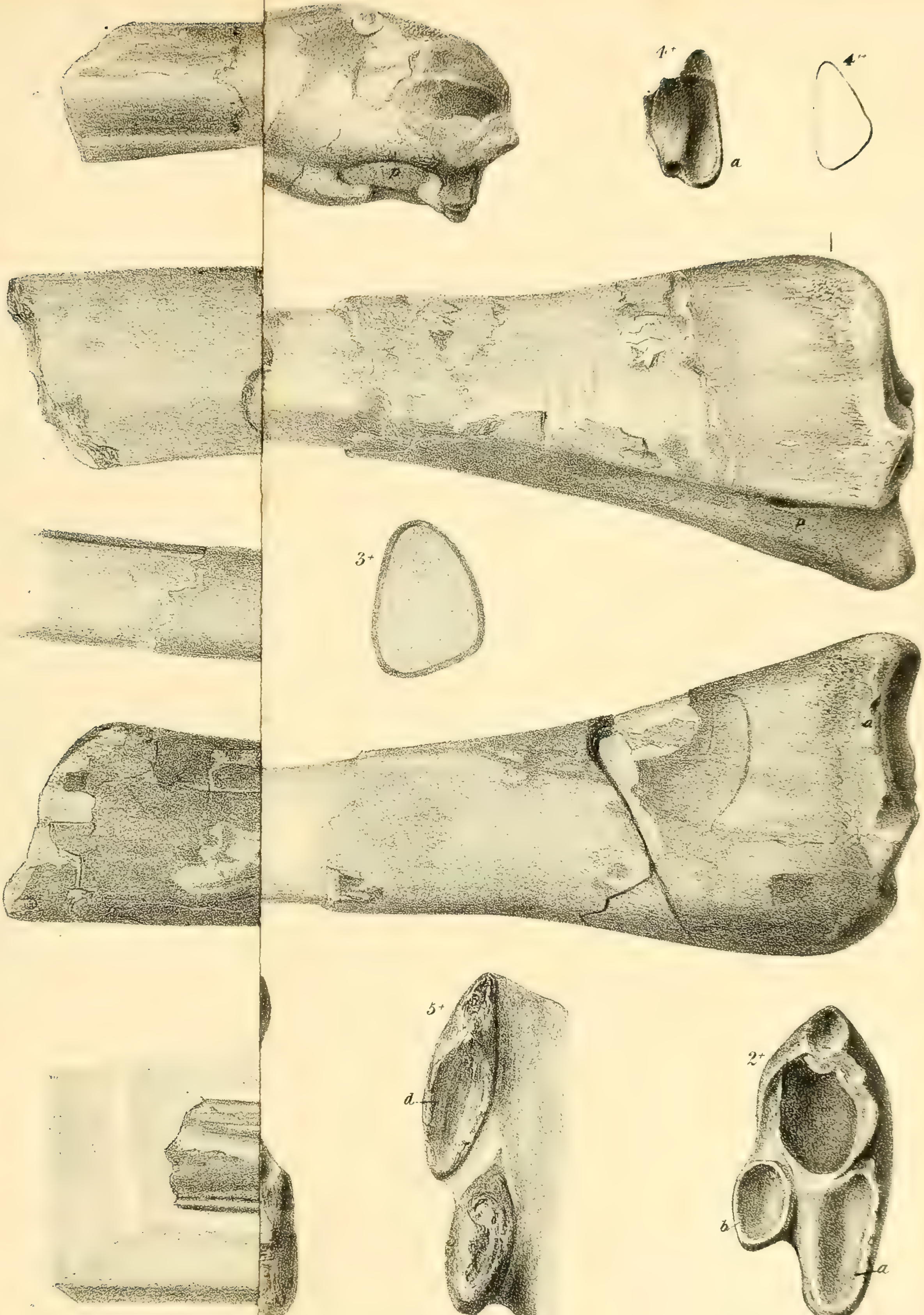
4**. Transverse section of the smallest part of the shaft.

From the Burham Chalk-pit, Kent. In the Collection of Jas. S. Bowerbank, Esq., F.R.S.

5. Portions of the shafts of the radius and ulna of *Pterodactylus compressirostris*, nat. size.

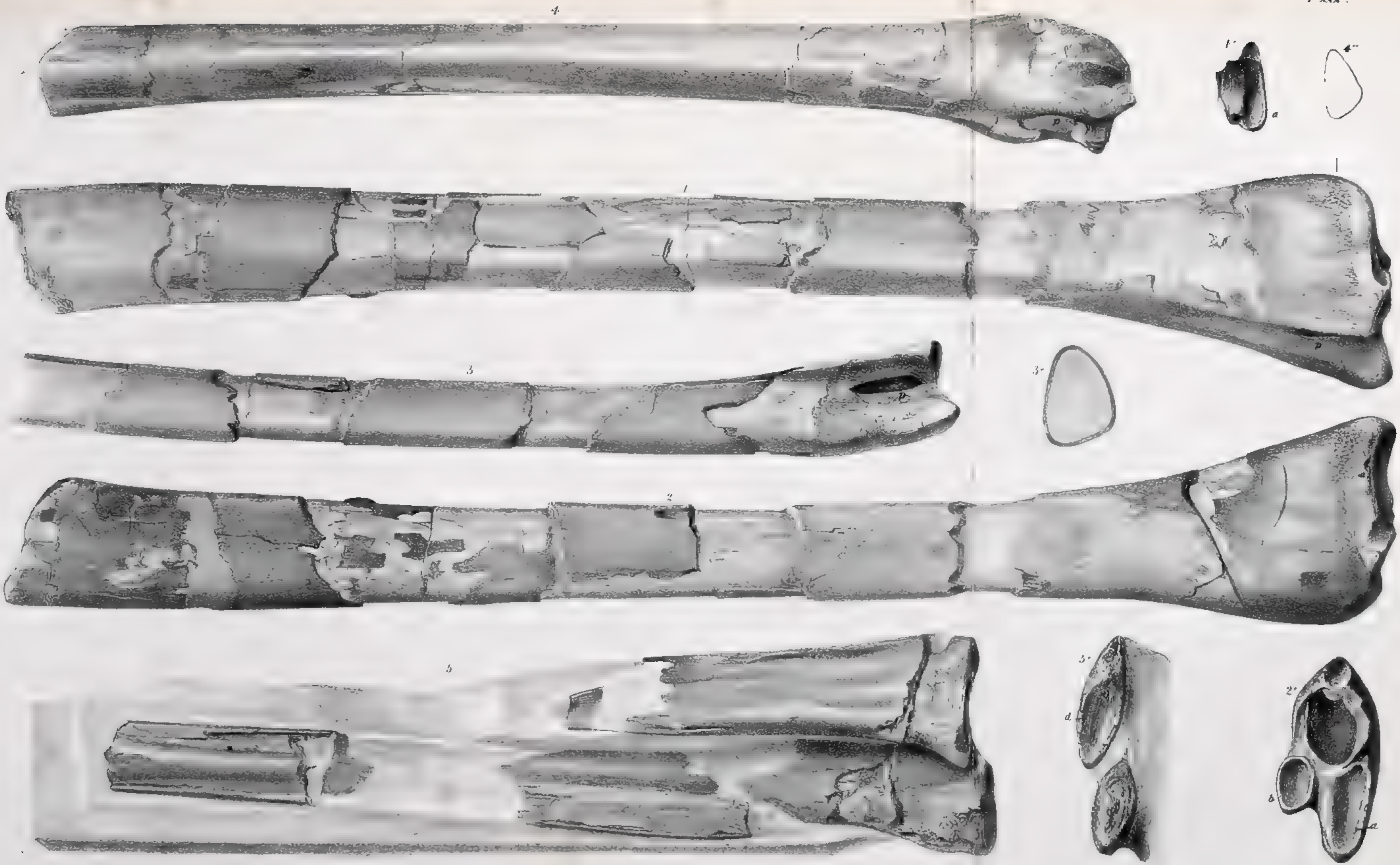
5.* The somewhat crushed and mutilated articular ends.

From the Burham Chalk-pit, Kent. In the Cabinet of Mrs. Smith, of Tonbridge Wells.



J. Dinkel, del. et lith.

Day & Son, lith.rs to the Queen



J. Dinkel del. et lith.

Day & Son lith^rs to the Queen

TAB. XXXI.

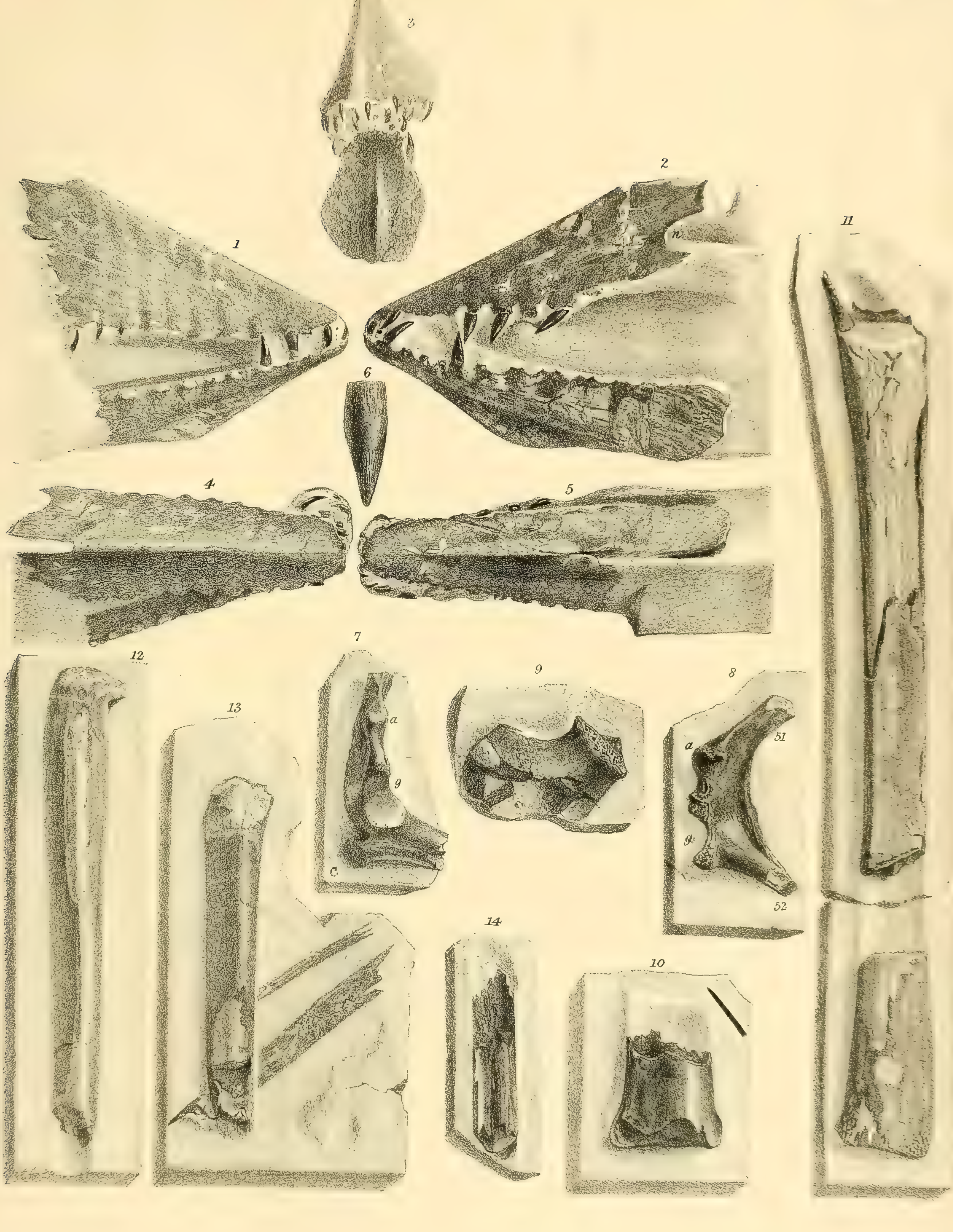
Pterodactylus giganteus, Bowerbank ; nat. size.

Fig.

1. Right side of the anterior end of both jaws.
2. Left side of ditto showing the beginning of the external nostril, *n*.
3. Front view of both jaws, which are a little distorted.
4. Upper surface of the upper jaw.
5. Under surface of the lower jaw.
6. A tooth, magnified.
7. Coalesced ends of scapula, 51, and coracoid, 52, showing the glenoid cavity, *g*.
8. Side view of ditto. *a*, acromion.
9. A fragment of bone in the same block of chalk with the scapular arch, probably a piece of the sternum.
10. Mutilated end of a long bone.
11. The great part of the shaft of a long bone of the wing.
12. Proximal portion of the shaft of probably the tibia.
13. Two portions of long bones, and a portion of a rib.
14. A fragment of a long bone.

All the above parts are from the Burham Chalk-pit, Kent, with the exception of figs. 10 and 11, which are from the Halling Chalk-pit, in the same county. In the Museum of James S. Bowerbank, Esq., F.R.S.

T XXXI



TAB. XXXII.

Fig.

1. Section of the ulna of a Pelican (*Pelecanus onocrotalus*), recent.

2. Proximal end of one of the bones of the wing-finger of the *Pterodactylus compressirostris*.

3. Portion of the shaft, probably of the femur of a large Pterodactyle?

3′. Form of the transverse section of ditto.

4. Three views of the distal trochlear joint of one of the long bones, probably the metacarpal of the wing-finger, of a large Pterodactyle?

5. Two views of a similar, but less mutilated bone.

From the Middle Chalk of Kent.

6, 6′. Two views of a fragment of one of the long bones of a large Pterodactyle.

7. A portion of the shaft of a long bone of a large Pterodactyle.

8, 8′, 8″. Three views of a portion of a humerus of a smaller Pterodactyle.

From the lower Green-sand, near Cambridge.

All the figures are of the natural size.

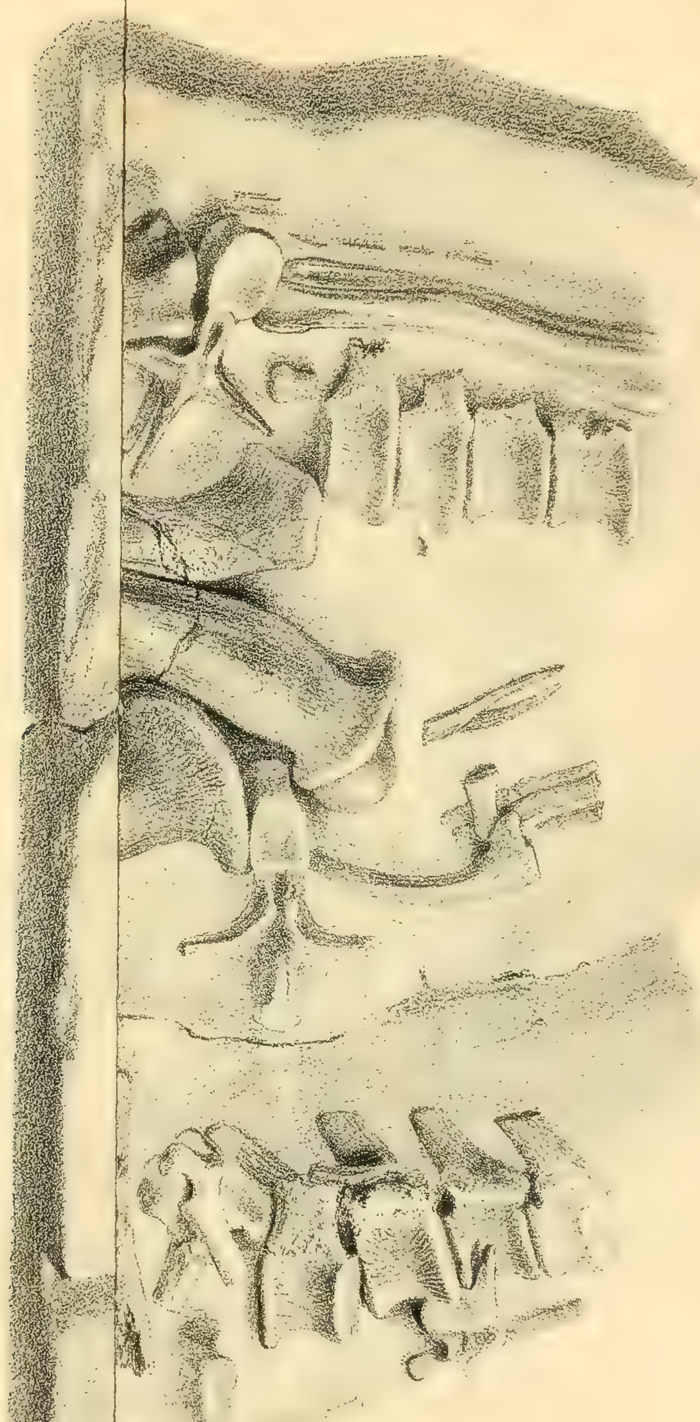

1
6
2
8'
8
6'
8''
3
3'
7'
5'
c
7
c
4
a
b
a
5
b
p

TAB. XXXIII.

Iguanodon Mantelli, scale of 2 inches to a foot.

A considerable portion of the skeleton in a block of the Kentish Rag variety of the Green-sand Stone Formation.

Discovered by Mr. Bensted, of Maidstone. In the Collection of the British Museum.

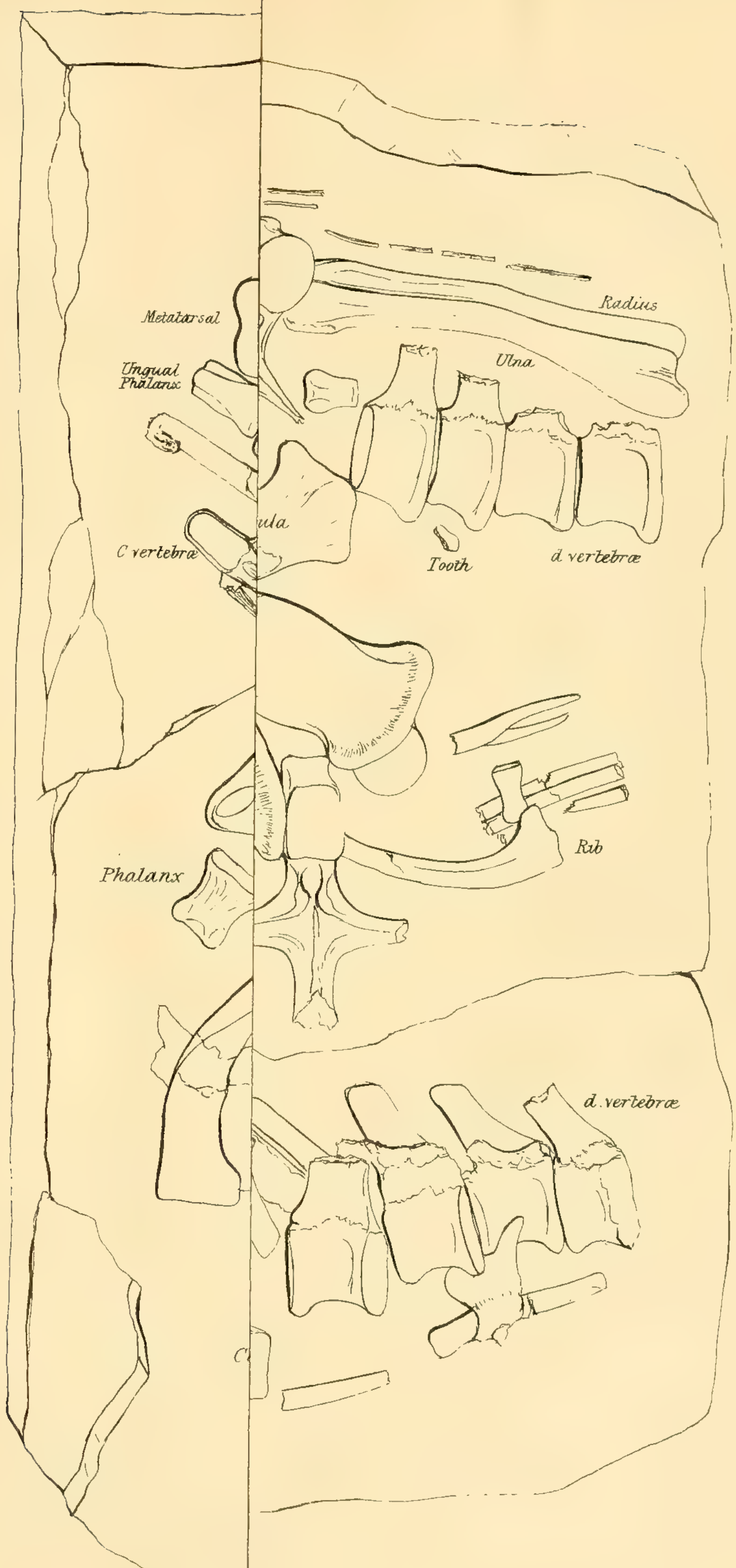


T. Ienkel, del.

' Dinkel del et lith

TAB. XXXIV.

Outline of the same specimen, with the names inscribed on the best preserved bones: in the vertebræ, *d,* is "dorsal," and *c,* "caudal."



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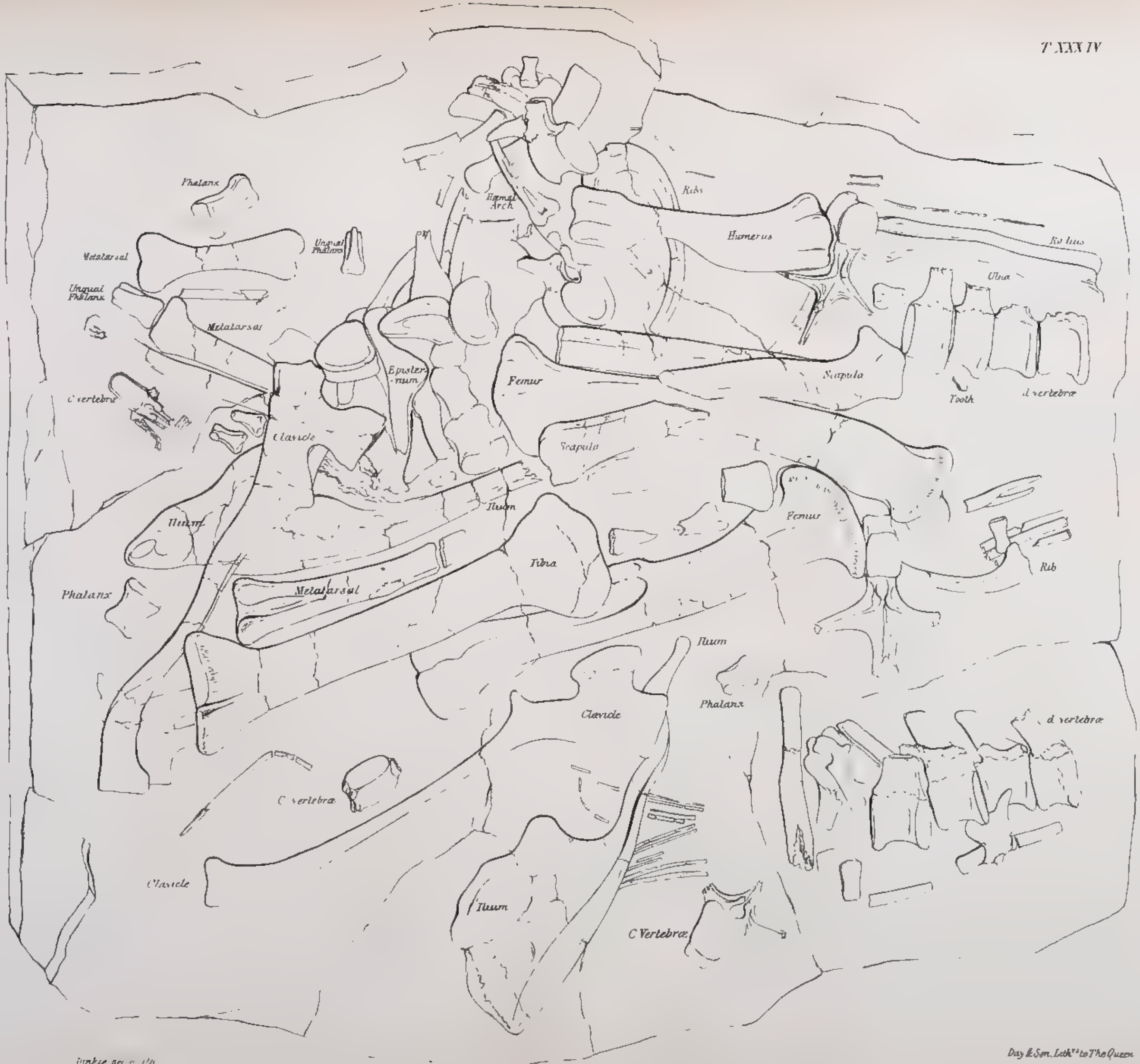

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TAB. XXXV.

Iguanodon Mantelli, nat. size.

Side view of a dorsal vertebra.

p. Parapophysis, or lower transverse process, with the surface for the head of the rib.

d. Fractured base of diapophysis or upper transverse process.

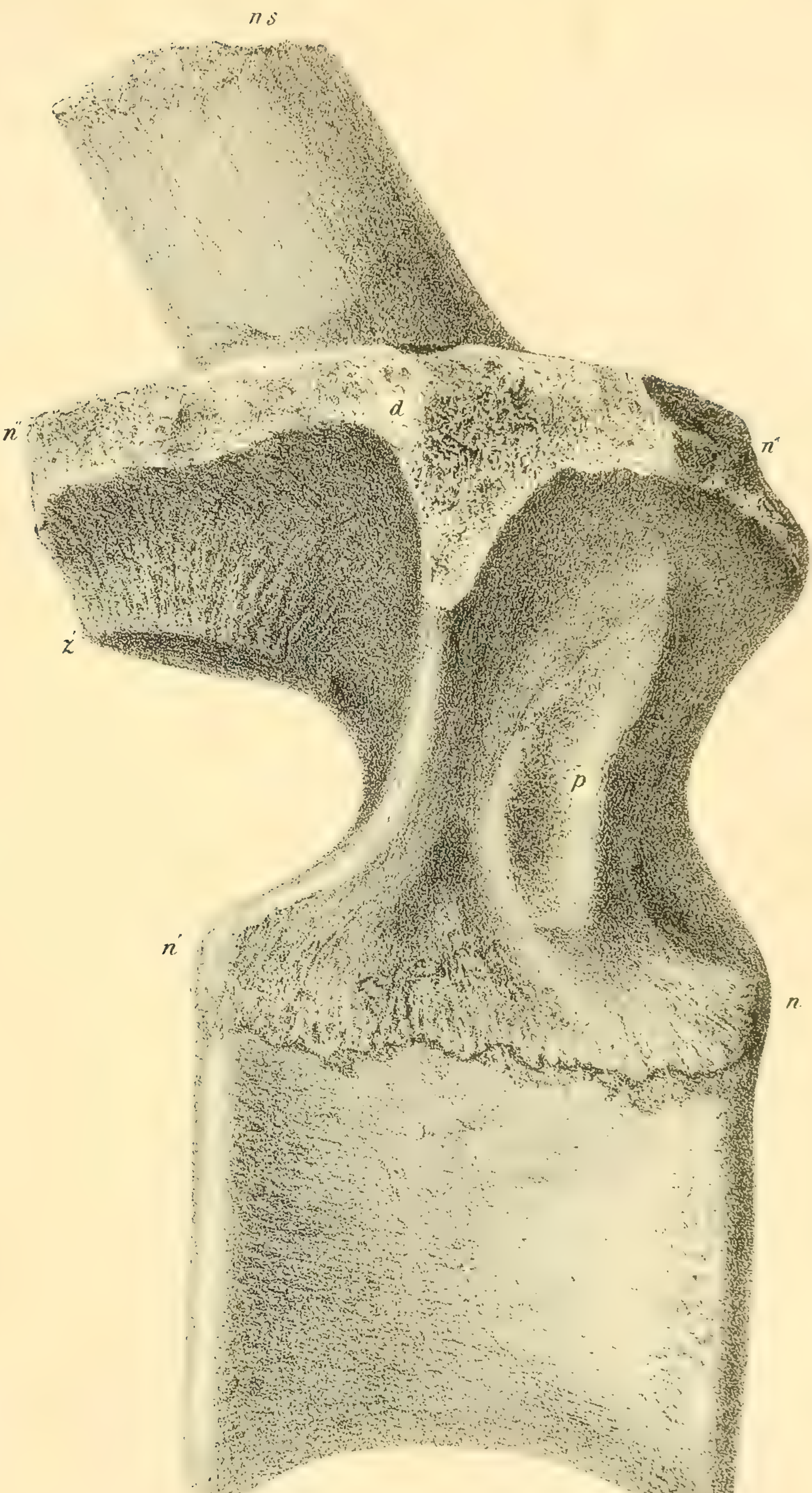
n, n'. Base of neurapophysis.

n, n''.* Neural platform.

z'. Posterior zygapophysis.

ns. Neural spine.

From the Kentish Rag. In the Collection of the British Museum.


ns
d
n''
n'
z'
p
n'
n.

TAB. XXXVI.

Iguanodon Mantelli, nat. size.

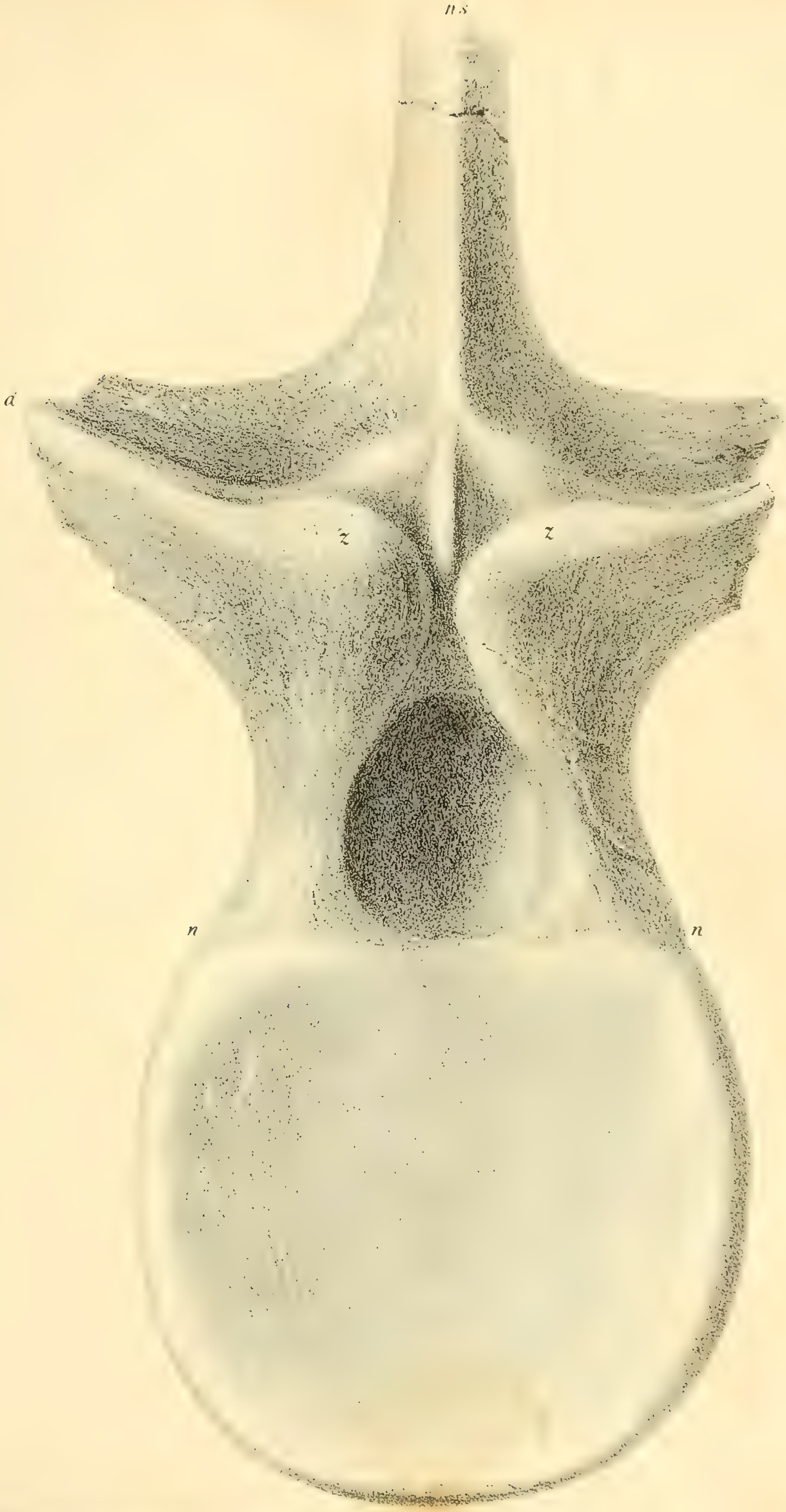
Front view of a dorsal vertebra.

n, n. Base of neurapophysis.

z, z. Anterior zygapophyses.

d. Base of diapophysis.

From the Kentish Rag. In the Collection of the British Museum.


ns
a
z
z
n
n

TAB. XXXVII.

Iguanodon Mantelli, nat. size.

Fig.

1. Front view of a caudal vertebra.
2. Side view of ditto.
3. Under view of ditto.
4. Under view of another caudal vertebra.

From the Kentish Rag, near Maidstone. In the Collection of the British Museum.

T. XXXVII.

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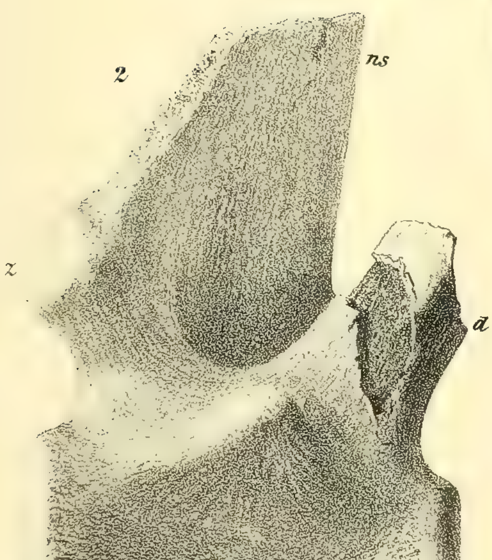

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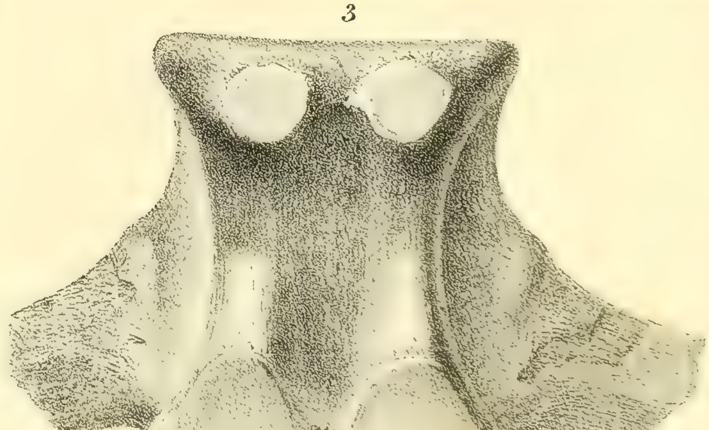

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

SUPPLEMENT No. I.

Pages 1—19; Plates I—IV.

PTEROSAURIA (Pterodactylus).

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

Issued in the Volume for the Year 1857.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1859.

SUPPLEMENT (No. I)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE CRETACEOUS FORMATIONS.

ORDER—*PTEROSAURIA*, Owen.

Genus—PTERODACTYLUS, *Cuvier.*

IN the 'Monograph of the Fossil Reptilia of the Chalk Formations,' p. 103,* the occurrence of remains of a large Pterodactyle in the Green-sand formation near Cambridge, was noticed, and portions of the wing-bones were figured in Tab. XXXII, figs. 6—8.†

The Woodwardian Museum of the University of Cambridge has subsequently been enriched by successive acquisitions of fossils, obtained, chiefly through the exertions of LUCAS BARRETT, Esq., F.G.S., from the same stratum of 'Upper Green-sand,' near Cambridge, where I had the opportunity of inspecting them last year. All those belonging to the *Pterosauria* have since been liberally transmitted to me by my friend PROFESSOR SEDGWICK for description and illustration in the Monographs of the Palæontographical Society, and I have subsequently received a few highly interesting additional examples of Pterodactyle remains from sources which will be duly acknowledged in the sequel.

* Volume of the Palæontographical Society, 4to, 1851. † Ib.

Pterodactylus Sedgwickii, *Owen*. Jaws and teeth, Tabs. I and III.

The specimen (Tab. I, fig. 1, *a*, *b*, *c*, *d*) is the fore part of the upper jaw, containing the first seven sockets of the teeth, in a few of the anterior of which the base of the tooth is retained. The first two sockets open upon the obtuse extremity of the jaw (fig. 1, *c*), and have a direction showing that their teeth projected obliquely forward, so as to prolong the prehensile reach of the jaw; the second and third sockets are the largest, and cause a slight transverse swelling (fig. 1, *b*); the fourth is suddenly smaller, and the three following retain nearly the same size, or show a slight increase as they pass backward. The apertures of the sockets are elliptic, with the long axis extending obliquely from before outward and backward, not parallel with the axis of the jaw; the plane of the outlet inclines slightly outward (fig. 1, *c*). The interval between two sockets is about half the long diameter of each. On one side of the figured specimen the fifth socket is obliterated. The anterior termination of the jaw is obtuse; the sides are smooth, flat, converging at an acute angle to what almost forms a ridge above (fig. 1, *c*, *d*); the jaw gradually increases in vertical diameter as it proceeds backward, the upper contour being straight as far as it can be traced in the fossil. The palatal surface is entire, narrowest between the second sockets, suddenly broader and flat between the third pair, retaining about the same breadth, but with a slight convexity and feeble indication of a median ridge in the rest of its extent, the ridge not being so strongly marked as it appears in fig. 1, *b*.

The Pterosaurian nature of this fossil is shown by the extreme thinness of the compact bony wall of the jaw; its relation to the genus *Pterodactylus*, as contradistinguished from the *Rhamphorhynchus*, V. Meyer, is proved by the terminal position of the sockets; and sufficient of the outer side wall of the jaw is preserved to show that the nostril did not advance so far forward as in *Dimorphodon*—the generic form of Pterodactyle from the Lower Lias.

By its size and true or proper Pterodactyle affinities the present specimen most resembles *Pterodactylus Cuvieri* of the Chalk, (Monog. cit., Tab. XXVIII); but it offers the following well-marked differences: a greater proportional size of the anterior sockets, with a corresponding expansion of the fore part of the jaw; a greater number and closer arrangement of the sockets; a greater depth of the jaw, in proportion to the breadth of the palate. The extent of the jaw, *e. g.*, containing the first seven sockets, in *Pterodactylus Sedgwickii*, is 2 inches 9 lines; but in *Pterodactylus Cuvieri* it is 3 inches 6 lines: the depth of the jaw, above the third socket, in *Pter. Sedgwickii*, is 14 lines; in *Pter. Cuvieri* it is 8 lines; whilst the breadth of the palate between the third pair of sockets is only 1 line less in *Pter. Cuvieri* than in *Pter. Sedgwickii*. It needs only to compare the fore part of the jaw of the Great Chalk

Pterodactyle (Monog. cit., Tab. XXVIII, figs. 1—4) with the same part of the still larger species from the Green-sand (Tab. I, figs. 1 and 2), to be convinced of their specific distinction.

The difference is still more marked between *Pterodactylus Sedgwickii* and *Pterodactylus compressirostris* (Tab. XXVIII, figs. 8, 9, 10). The rapid increase of depth as the jaw extends backward, in *Pter. giganteus*, Bk. (ib., Tab. XXXI, fig. 1), shows that that comparatively small species cannot be the young of the present truly gigantic Pterodactyle of the Upper Green-sand. I have no hesitation, therefore, in basing on the above-described fossil a new species, at present the largest known in the order of Flying Saurians, which I propose to dedicate to the Woodwardian Professor of Geology in the University of Cambridge, who for forty years has discharged the duties of that office with exemplary zeal and a rare eloquence, has almost created the museum still called (Woodwardian,) and has enriched geological science by original researches which have thrown light on its most obscure and difficult problems.

The next fossil selected from the Pterosaurian series of Green-sand fossils for present description is the fore part of the jaw figured in Tab. I, figs. 2, *a*, *b*, *c*, *d*. This contains about the same number of sockets in the same extent of jaw as in fig. 1; and the last four sockets present about the same extent of interspace, with the same diminution of size, as compared with the two preceding sockets. But the walls of these sockets form no lateral expansion, the depth of the jaw is less, and the flat sides converge to a sharper ridge, fig. *c*; the aspect of the sockets is also more obliquely outward, the interspace between the pairs is narrower, and this is traversed by a median groove ⅛th of an inch across, fig. *b*. Were this specimen a part of an upper jaw, it would indicate a distinct species from *Pterodactylus Sedgwickii*, as exemplified by fig. 1; but I regard fig. 2 as being the fore part of a lower jaw, and consequently as most probably belonging to the same species. The minor depth of the bone accords with the proportions of the lower jaw in *Pter. giganteus* (Monog. cit., Tab. XXXI, figs. 1 and 2); and the sockets are directed more obliquely outward, as they likewise are in the lower jaw of *Pter. giganteus,* as compared with the upper one of the specimen of that species, in which both jaws of the same head have been preserved. In the belief, therefore, that fig. 2, *a*, *b*, represents part of the under jaw of *Pterodactylus Sedgwickii,* the median groove on the upper or oral surface of the prolonged 'symphysis mandibulæ' (fig. 2, *b*) suggests that it may have served to lodge a long filiform tongue, perhaps bifurcate at the end, as in the Leptoglossal Lizards of the present day. The same thin outer wall, and capacious cavity filled by matrix, and probably in the living reptile by air, characterise the lower (fig. 2, *c*), as they do the upper, jaws of *Pterodactylus Sedgwickii.* In one of the sockets of the lower jaw part of the hollow base of an old tooth is preserved, with the sharp slender point of a new tooth projecting from the inner side of the socket (Tab. I, fig. 2, *d*), showing the same relative position of the matrix of the successional tooth, as may be observed in the existing Crocodile.

Pterodactylus Fittoni, *Owen*. Jaws and teeth, Tab. I, figs. 3, 4, 5.

Figure 3, *a*, *b*, &c., shows the fore part of the upper jaw of a Pterodactyle, with the first and second pairs of alveoli. In the minor depth of the jaw, compared with its basal breadth, in its more obtusely rounded upper surface, and in the greater extent of space between the alveoli of the same size, this maxillary fragment indicates a very distinct species from the *Pterodactylus Sedgwickii,* but one probably not much inferior in size. I propose to dedicate it to my friend, Dr. Fitton, F.R.S., one of the founders of the Geological Society of London, and who may be regarded as the discoverer of the system now called "Neocomian," which includes the Green-sand matrix of the Flying Reptiles under consideration. The sockets in the fragment (fig. 3) may answer to the second and third in fig. 1, though there scarcely seems room for a pair in advance of the foremost in the specimen figured; be that as it may, the distance between the first and second socket in the specimen of *Pterodactylus Fittoni* is, relatively to the size of the socket, greater than the interval between the second and third sockets in *Pterodactylus Sedgwickii,* and much greater than that between the second and third sockets. The outer wall of the largest anterior socket in *Pter. Fittoni* is much less prominent than in *Pter. Sedgwickii*, and the lateral expansion of the fore part of the upper jaw must have been relatively less; the form of the bony palate is different, there being a distinct though shallow longitudinal groove on each side a low obtuse median ridge. The diastema between the second and third tooth is shown to exceed the long diameter of the second socket, recalling the proportion of the interspaces in *Pterodactylus Cuvieri* (Monog. cit., Tab. XXVIII, fig. 4), but the jaw is broader in proportion to its height in *Pterodactylus Fittoni.*

Figure 4, *a* and *b*, is a fragment of one side of the fore part of the upper jaw, showing three alveoli, and agreeing in general proportions with the *Pterodactylus Fittoni.*

Fig. 5 is the fragment of a jaw, showing a single elliptical socket, 5 lines in long diameter (*a*), and with the plane inclined a little outward, as at *b*. The widely open cancellous structure of the bone is well shown on the inside of this fragment, as at *c*.

Pterodactylus. Sp. inc.

Tab. I, fig. 6, is a portion of an upper jaw, including a part of two sockets, in one of which the root of the tooth remains. Three views of this fragment are given, of the natural size: *a* showing the alveolar border, *b* the broken margin exposing the tooth, and *c* the outer wall of the jaw. This part of the wall is nearly flat, very

slightly convex below, and as slightly concave above, vertically; the upper margin showing no indication of any bend or inclination to the upper border of the jaw, the height or vertical diameter of which remains conjectural; that it was, at least, one third more than the portion preserved, may be estimated from the extent of the socket of the tooth being equal with the preserved part of the wall (fig. 6, *b*). A coat of roughish 'cæmentum,' one third of a line thick, is preserved upon the upper half of the tooth-root; below this is seen the smooth dentine; and where it is broken, the pulp-cavity is exposed, filled by the Green-sand matrix. The length of the implanted part of this tooth is 1 inch 4 lines, the long diameter of the transverse fracture at the base of the crown is $\frac{1}{2}$ an inch, the short diameter is $4\frac{1}{2}$ lines. Estimating the length of the exserted enamelled crown to equal that of the inserted cemented base of the tooth of a Pterodactyle—and I have known it more in the long anterior laniariform teeth—we may assign a length of 2 inches 8 lines to the teeth implanted in the part of the upper jaw here described. The interspace between the two sockets is $3\frac{1}{2}$ lines, or half that of the long diameter of the socket; the plane of the opening of the socket, and the interspace, present the same obliquity as they do in *Pterodactylus Sedgwickii* (fig. 1); and as the proportion of the interspace to the socket is also the same, the present fragment has most probably belonged to a larger individual of the same species. Since the outer border of the sockets does not swell out beyond the outer wall of the jaw, the fragment has been part of jaw behind the anterior swelling caused by the proportionally large prehensile teeth; and as, from the analogy of known Pterodactyles, the teeth succeeding those anterior ones are not of larger size, but are usually smaller, at any posterior part of the jaw, we may, therefore, with due moderation, frame an idea of the Pterodactyle to which the maxillary fragment (fig. 6) belonged, as surpassing in size that to which the portion of jaw (fig. 1) belonged, in the proportion in which the socket in fig. 6, *a*, exceeds the last socket in fig. 1, *b*. Such an idea impels to a close scrutiny of every character or indication of the true generic relation of the present fragment in the Reptilian class; but the evidence of the large and obviously pneumatic vacuities, now filled by the matrix, and the demonstrable thin layer of compact bone forming their outer wall, permit no reasonable doubt as to the pterosaurian nature of this most remarkable and suggestive fossil. All other parts of the Flying Reptile being in proportion, it must have appeared, with outstretched pinions, like the soaring Roc of Arabian romance, but with the demoniacal features of the leathern wings with crooked claws, and of the gaping mouth with threatening teeth, superinduced.

The last portion of jaw of Pterodactyle from the Cambridge Green-sand which will here be described, is that figured in Tab. I, fig. 7, *a*, *b*, *c*, *d*. It is part of the lower jaw, and indicates a smaller individual of *Pterodactylus Sedgwickii* than the specimens, figs. 1 and 2. In a longitudinal extent of $2\frac{1}{2}$ inches, six successive sockets are shown, but with only the two middle pairs perfect. Their orifices have the same

obliquity as in fig. 2; and the surface of the bone between the right and left sockets shows the same median longitudinal groove. Opposite the middle sockets the sides of the jaw are preserved nearly to the median inferior ridge, as shown in fig. 7, *c*; these sides being flat and straight, and giving the transverse section shown at fig. 7, *d*. The intervals of the sockets are a little wider, proportionally, than in some of those in fig. 2, but not more than a hinder position in the jaw would account for, without having recourse to a distinction of species to explain it.

Two species, however, are satisfactorily established, both of them distinct from any of the known large Pterodactyles of the Chalk, by the portions of jaws from the Upper Green-sand near Cambridge, viz., *Pterodactylus Sedgwickii,* with more approximated alveoli (Tab. I, figs. 1 and 2, with probably 6 and 7); and *Pterodactylus Fittoni* (ib., figs. 3, 4, and 5).

To which of these large species the teeth and bones next to be described belong is not satisfactorily determinable, but indications of their appertaining to more than one such species now and then occur with more or less significancy.

Teeth.

Various teeth, but few quite entire, have been rescued by the care and perseverance of Mr. Lucas Barrett from the rubbish of fragmentary fossils accumulated during the diggings for phosphatic nodules in the Green-sand deposits near Cambridge. Guided by the proportions of length to breadth, by the elliptic section, and the concordance of the minute markings on the crown and base with those on the portions of teeth, as in Tab. I, fig. 2, *d*, and 6, *b*, remaining in the jaws of *Pterodactylus Sedgwickii,* many of the above detached teeth can be satisfactorily referred to the genus, if not to that particular species.

The base or implanted part of one of the largest of these teeth is figured of the natural size in Tab. I, fig. 10. It has belonged to a Pterodactyle as large as that represented by the fragment of jaw (fig. 6), if not to the same individual; it presents the same elliptical transverse section as the implanted base of the tooth in fig. 6, *b*; shows a widely excavated pulp-cavity at the base, and gradually tapers to the crown; the cement, about $\frac{1}{3}$d of a line in thickness, is roughened by longitudinal grooves, not continuous for any great length, but uniting, or bifurcating, in an irregular reticulate pattern, forming long and very narrow meshes, the raised interspaces being equal in breadth to the grooves. In a few teeth the base shows an oblique depression, evidently due to the pressure of a successional tooth, as shown at Tab. I, fig. 8, *o*; in these the basal pulp-cavity is more or less filled up by ossification of the pulp. The enamel of the crown seems smooth and polished, and, under the lens, shows only extremely delicate, slightly and irregularly wavy, longitudinal, but often interrupted or confluent, ridges. The crown is straight in a few teeth, as at Tab. I, fig. 9, but

more commonly it is bent, as it is in the tooth of the great Pterodactyle from the Chalk figured in the above-cited 'Monograph on Cretaceous Reptilia,' Tab. XXVIII, fig. 5. In general, the transverse section of the crown is less truly elliptical than that of the base, owing to its being a little flattened on one side. The smaller teeth, probably from the back part of the dental series, are rather more curved than the larger ones (Tab. III, figs. 16—20).

Vertebræ of Pterodactylus. Tab. I, figs. 11—14. Tab. II.

The most instructive specimens from the Cambridge Green-sand are those which have afforded the precise and hitherto unknown characters of certain vertebræ of *Pterodactylus*. Viewed as indicative of the generic character of these bones, they give the earliest known example of the "procoelian" type of vertebræ* in the Reptilian class, being the first cup-and-ball vertebræ, with the "cup" at the fore part of the centrum, met with in the ascending order of strata. It cannot be doubted that this structure prevails in the moveable vertebræ of the neck and back of all *Pterosauria*, and must be predicated of the *Dimorphodon*† of the Lias as well as of the *Pterodactylus* of the Green-sand, in which the structure is now clearly demonstrated. The chief difference which the Pterodactyle presents in this respect from modern Lizards is, that both the cup and ball are of a more transversely extended elliptical shape in most of the vertebræ of the flying Saurian.

Amongst the numerous vertebræ submitted to me were specimens of united, or partly united, "atlas and axis."

The atlas consists of a centrum (Tab. I, figs. 11 and 12, *c*), of two slender styliform neurapophyses (ib., *n*), and of a very small discoid neural spine. The centrum is so short as to be discoid; it is flat where it joins and becomes anchylosed to the axis (*x*), and is concave for the occipital tubercle: this cup is circular; its depth is shown in the section of the anchylosed atlas and axis, fig. 12. The neurapophyses (*n*), resting on each side of the upper half of the centrum of the atlas, converge and articulate above with two small tubercles, as shown in fig. 13, on the fore part of the neural arch of the axis; the neurapophyses almost meet, but do not unite above the neural canal.

The body of the axis is eight times longer than that of the atlas; it expands posteriorly, and terminates by a transversely elliptical ball (*b*) at the upper part of that end, and in a pair of thick, short, obtuse, diverging apophyses (*p*), at the lower part. There is a rudimental hypapophysial ridge, fig. 12, *h*, from the middle and toward the fore part of the under surface of the centrum; the extent to which this surface

* 'Monograph of Fossil Reptilia of the London Clay,' 4to, vol. for 1850, p. 11.

† 'Reports of the British Association,' 1858.

descends below the hinder ball, and between the apophyses (p), is shown at Tab. I, fig. 12, x.

The centrum of the axis vertebra is confluent with the neural arch, fig. 11, n, x; at the middle of the side, apparently crossing the line of junction, is a large subcircular aperture, which leads directly into the widely cancellous structure of the bone, below the neural canal. This vacuity (fig. 11, o) answers to the " foramen pneumaticum" in the vertebræ of birds, and doubtless admitted a production from the air-cells extending along the neck of the Pterodactyle into the cancelli of the osseous tissue. The neural arch rests upon the three anterior fourths of the centrum ; it expands as it passes backward ; and there, also, as it rises, until it sends off from each posterior angle the zygapophysis (Tab. I, fig. 11, z), which has a tubercle above, and a flat articular surface below, looking downward and a little outward and backward. The small tubercles at the fore part of the neural arch, shown in fig. 13, to which the neurapophyses of the atlas are ligamentously connected, may be the stunted homologues of anterior zygapophyses. The neural spine begins by a low ridge between those tubercles, increasing rapidly in thickness behind; but it has not been preserved in its full height in any specimen.

In the small atlas and axis figured in Tab. II, figs. 1—4, the line of suture between the bodies of these two vertebræ is distinct. In a somewhat larger specimen, the centrum of the atlas was separable by a smart blow, and showed the true anterior surface of that of the axis, as shown in Tab. I, fig. 13 ; this surface is very slightly concave, with a submedian prominence. The neural canal expands at its posterior outlet.

The small atlas and axis (Tab. II, figs. 1—4) not only differ in size from the specimen (figs. 5 and 6), but also in the smaller relative size of the articular surface of the zygapophysis, and the greater relative expansion of the back part of the centrum: the specimen belongs to another species of Pterodactyle. On comparing the atlas and axis of the Pterodactyle with that of the bird, the Ostrich for example, the atlas in the bird is represented by the neurapophyses, which have coalesced below with a hypapophysis, forming an irregular ring of bone. The centrum has coalesced with that of the axis, forming a small prominence, convex anteriorly, and filling up the vacuity at the upper part of the cup excavated in the fore part of the hypapophysis; the neurapophyses are broad in the bird, and overlap the anterior zygapophyses in the axis; they meet above the neural canal, but long retain the separating fissure there, in the Ostrich; the centrum of the axis is broader before than behind. A short process, like a connate pleurapophysis, from the fore part of the centrum, unites with a diapophysis from the neural arch to form an arterial canal. The pneumatic foramen is behind the diapophysis, and conducts to the cancellous tissue of the neural arch. The centrum is produced into a strong hypapophysis below the posterior articular surface; but not expanded laterally into transverse processes, answering to parapophyses, in the Pterodactyle. The hinder articular surface of the centrum of the axis in the

bird is convex transversely, but concave vertically, not simply convex, as in the Pterodactyle; thus a portion of the vertebra of that reptile, notwithstanding its pneumatic structure, might be distinguished from the vertebra of a bird.

In the ordinary neck-vertebræ of the Pterodactyle the centrum is oblong, subdepressed, slightly compressed at the middle, subcarinate (Tab. II, figs. 11, 12, *h*), or with a low obtuse hypapophysis (fig. 18) at the fore part of the under surface, which expands laterally to join the base of the anterior zygapophyses (ib. *a*). The back part of the centrum expands and bifurcates into the short, thick, obtuse parapophyses (figs. 11 and 18, *b*), the anterior concavity (fig. 10, *c*) is a long transverse oval, with the upper border somewhat produced: the hinder ball (fig. 8) has a similar transversely extending elliptical figure, directed a little upwards; it appears to be tilted up by the curve of the under surface of the centrum, above the level of the terminal tuberous parapophyses (*p*). A large pneumatic foramen (figs. 7, 13, 15, *o*) of an elliptic form, opens upon the middle of each side of the centrum, close to the anchylosed base of the neurapophysis. The texture of the centrum (fig. 19) presents a few very large cancelli, which communicated by the pneumatic foramen with the cervical air-cells. The smooth outer wall of the centrum is a very thin but compact plate of bone: it becomes a little thicker where it forms the articular cup and ball.

The neural arch, between the notches of the nerve-outlets, is not quite two thirds the length of the centrum. The hinder notch is the deepest; the arch is low, broad exteriorly, less concave on each side than it is before and behind (Tab. II, fig. 17), with the four angles somewhat produced, and supporting the articular surfaces, of which the two anterior (fig. 18, *a*) look upward and inward, the two posterior (fig. 16, *z*) downward and backward. The sides of the neural arch extend outward so as to overhang those of the centrum (fig. 18). The posterior zygapophyses (*z*), do not extend so far back as the articular ball of the centrum.

Figs. 7 to 11 give five views of the natural size of a middle cervical vertebra, which, according to the proportions of *Pterodactylus suevicus*, Qnstd.,* may have belonged to a Pterodactyle with a first phalanx of the wing-finger of about one foot in length. In fig. 12 the under surface of the centrum is well preserved; it differs from that of the larger cervical vertebra (figs. 7—11) in being flatter from side to side, and in being concave instead of convex from before backward; the concave contour being due to the median production, gradually extending into the obtuse hypapophysis (*h*) at the fore part. This difference indicates that the present vertebra had a more advanced position in the cervical series than fig. 7, which may probably have been the sixth. The superior breadth of the neural arch over the centrum is well shown in fig. 12; and the relative positions of the zygapophysis (*z*), the articular ball (*b*), and the parapophysis (*p*), at the hinder end of the vertebra, are seen in fig. 13, which is a side view of the same vertebra.

* Quenstedt, 'Ueber *Pterodactylus suevicus*,' 4to, 1855.

Figs. 14, 15 and 16 show a smaller cervical vertebra, of a more depressed form, not due to crushing. The centrum is much depressed; the pneumatic foramen (fig. 15, *o*) partakes of the same modification of form, and is a longer ellipse than in the vertebra (fig. 7); the neural canal retains its normal cylindrical shape, with slightly expanded outlets. The form of the posterior zygapophysis is perfectly preserved on one side, in fig. 11, *z*, and the articular surfaces on both sides in fig. 16, *z*; they are relatively larger than in fig. 11. In fig. 15 more of the base of the neural spine remains than in most other specimens.

Figs. 17 and 18 are of a rather shorter and probably more advanced cervical vertebra, but of very similar proportions; in it the neural arch (fig. 17) is more entire than in most specimens, the anterior (*a*) as well as posterior (*z*) zygapophyses being preserved; the more frequent loss of the anterior pair is due to their being more slender and more produced. The under surface of the centrum (fig. 18) shows no rising of the middle part, the hypapophysis having a less extended base than in the vertebra, (fig. 12.) The inner surface of the anterior zygapophysis (fig. 18, *a*), is divided by a notch from the border of the articular concavity of the centrum.

Fig. 19 gives a view of a section of a mutilated cervical vertebra, nearly equal in size with fig. 7, and similar in form. The shape of the neural canal, the large cancelli, and the thin superficial compact crust of the bone, are well shown in this section.

At the base of the neck, or beginning of the back, the vertebræ suddenly decrease in length; the hypapophysis disappears, or is represented only by a slight production of the lower border of the anterior cup; the parapophyses are less produced, the lower surface of the centrum is flattened, and presents the quadrate form shown in figure 20. There is now a considerable development from the fore part of each side of the neural arch and contiguous part of the centrum, and thereby the last cervical or first dorsal vertebra of the Pterodactyle more resembles the corresponding vertebra of the bird. The parapophysis, diapophysis, and rudimental rib coalesce around the vertebraterial foramen; an oblique ridge is continued from the upper border of the anterior articular cup upon the parapophysis; a parallel oblique ridge is continued from the anterior zygapophysis downward and outward upon the pleurapophysis; the diapophysis makes a low obtuse projection above the pleurapophysis and behind the zygapophysis. Above these developments the neural arch contracts from before backward, to an extent of 5 lines, as compared with a total vertebral breadth, anteriorly, of 1 inch 8 lines; it then rapidly expands, rising vertically at its fore part, and developing at its back part the posterior zygapophyses, the articular facets of which look more directly outward than in the long cervical vertebræ; the superincumbent tubercle (fig. 22, *c*) is more distinct from the facet (ib., *z*); the posterior zygapophyses are also much more approximated than in those vertebræ; they are separated behind by a semicircular concavity; the base of the neural spine in the vertebra here described measured 6 lines in length by 3 in breadth. The

pneumatic foramina are at the back part of the base of the diapophysis, as I have seen them in the cervical vertebra of a *Dinornis*. The articular surfaces of the centrum retain the transversely extended form, and are simply concave before and convex behind, which at once distinguishes the Pterosaurian hind-cervical vertebra from that of the bird.

In the dorsal region the vertebral centrum (fig. 24), retaining its shortness, gains in depth, and presents the more usual proportions of cup-and-ball reptilian vertebræ. The under surface (fig. 20) is smooth and even, very slightly concave lengthwise, convex transversely. The parapophysis disappears, and the diapophysis, which alone supports the rib, after the first or second dorsal, is sent off from a higher position in the neural arch (fig. 25).

Sacrum.

Fig. 26, Tab. II, shows parts of the bodies of three anchylosed sacral vertebræ, the first being demonstrated by part of its anterior concave articular surface (*a*) for the last lumbar vertebra. The groove for the passage of the nerve notches the back part of the parapophysis, close to the line of suture with the second sacral. In this vertebra the corresponding nerve-notch is more advanced, leaving a short sutural surface behind, indicative of a position of the neural arch crossing for a short extent the line of junction of the second with the third sacral centrum. The parapophyses of the second and third are sent off almost on a level with the lower surface of the centrum, which is flattened.

The fore part of the sacrum of a much larger Pterodactyle, from the Cambridge Green-sand, differing also in the less transverse convexity of the under part of the first centrum, measures 11 lines across the shallow anterior articular concavity, and 14 lines from the lower part of the centrum to the fore part of the base of the neural spine. The neural canal is circular and 2 lines in diameter; above it the neural arch rises like a vertical wall for 5 lines, where the spine has been broken off.

Caudal Vertebræ.

From the number of elongated caudal vertebræ in the series of fossils from the Cambridge Green-sand submitted to me—not fewer than seven—I believe the large Pterodactyle from that formation to have had a long tail, but moveable, not stiff through anchylosis of the vertebræ, as in *Pter.* (*Ramphorhynchus*) *Gemmingi, V.* Meyer.

The largest of these caudal vertebræ measures $1\frac{1}{2}$ inch in length; it is slightly

contracted in the middle; the fore part of the under surface is a little produced; the back part almost flat between the rudimental parapophyses; the shallow anterior concavity has resumed its transversely elliptical shape, and the hinder convexity is defined below by a shallow groove connecting the parapophyses. There is no pneumatic foramen, unless a small hole on each side the hinder outlet of the neural canal have served as such; the neural arch is long and low, quite one piece with the centrum, which extends beyond it posteriorly. It sends off short, obtuse zygapophyses before and behind, those in front extend beyond the cup of the centrum; the surfaces on those behind look downward and backward. The base of the spine is coextensive with the summit of the arch, but is narrow. The neural canal is much contracted. There is no indication of a hæmal arch, either by articular or fractured anchylosed surfaces. The diameter of the middle of this vertebra is 6 lines.

The caudal vertebra next in size measures 1 inch 5 lines. The base of the neural spine begins 2 lines behind the fore part of the arch, but terminates nearer the hind part; the nerve-grooves notch the hinder zygapophyses.

Three more slender caudal vertebræ present each a length of 1 inch 3 lines; the diameter at the middle is 5 lines in one, 4 lines in a second, $3\frac{1}{2}$ lines in the third vertebra, showing that they become more slender without losing length. A caudal vertebra 3 lines across the middle appears to have been nearly an inch in length; but both extremities are injured.

Frontal Bone (?)

As it is probable that the median symmetrical portion of bone (Tab. IV, figs. 6, 7 and 8) may belong to the cranium of one of the large Pterodactyles from the Upper Green-sand, its description follows that of the vertebræ.

It is 2 inches 4 lines long; 10 lines across its broadest part; 1 inch 2 lines in depth, to the surface where the piece has been broken away; the sides present a smooth concave plate of bone (fig. 6), as if the piece had been nipped between a finger and thumb, but quite symmetrically; the surface, which, on the supposition that those smooth concave facets were inner walls of the orbits, would be the upper one, and due to the frontal bone, is gently convex in the direction of its length, and has a median longitudinal ridge, which expands and subsides near the end most produced beyond the lateral depressions. I have observed a similar median ridge or rising upon the single frontal bone of the *Alligator lucius*, between the orbits, and upon the double frontal, supporting the median suture, in the *Rhynchocephalus* lizard of New Zealand. There is also an indication of such a median ridge in the figure of the cranium of *Pterodactylus suevicus*, in Professor Quenstedt's Memoir on that species (4to., Tübingen, 1855).

The most perfectly preserved of the lateral impressions (fig. 6) is of an oval form, 1 inch 3 lines in long diameter; it is well defined from the narrower upper surface (fig. 7) to which it stands at nearly a right angle; the curved border defining it is not produced. The whole of the substance of the bone between the lateral plates is occupied by a moderately open and apparently pneumatic cancellous texture (fig. 8); the outer wall of bone is compact, but extremely thin; the general structure is decidedly that of a volant Vertebrate, and most resembles that of a Pterodactyle.

The parts of the skeleton of the Pterodactyle which would afford a symmetrical median piece of bone, comparable with the present fragment, are—the sternum, the fore part of the upper and lower jaw, the sphenoid at the base of the skull, and the parietal and frontal bones at the upper part of the skull. The absence of any trace of cranial cavity at the lower fractured surface, more than an inch below the outer surface, opposes the choice of the parietal with lateral impressions of temporal fossæ: there remains, therefore, the frontal with the interpretation of the lateral depressions as parts of the orbits; but the depth of the smooth impressed plates, and their divergence as they descend, oppose this interpretation. I have no evidence of sternal ends of coracoids which would require articular depressions of such size and shape as the lateral ones on the fragment in question, on the hypothesis that it may be from the fore part of the sternum. Upon the whole, therefore, I have to acknowledge a degree of uncertainty as to the exact nature of the present fragment of the skeleton, most probably, of some large Pterodactyle.

Scapular Arch.

The mechanism of the framework of the wings in the Pterodactyle is much more bird-like than bat-like. The scapular arch is remarkably similar to that of the bird of flight. It consists of a scapula and coracoid, usually anchylosed where they combine to form the shoulder-joint.

The cavity for the head of the humerus, in *Pterodactylus macronyx* * (Tab. III, fig. 6), is oval, with the great end formed by the scapula; it is concave vertically, or in the direction of its long diameter, convex transversely, but least so near the scapula. If these proportions hold good in other species, they would serve to determine the scapular or coracoid portion of a glenoid cavity, when, as in the case of the fossils here described, the rest of the scapular arch had been broken away.

The upper (scapular) border of the glenoid cavity is prominent and well defined; the bone is moderately constricted beyond it, from without inward, whence the

* Buckland, 'Geological Transactions,' 2d series, vol. iii, pl. xxvii, x, 9.

scapula extends upward and backward, as a slightly bent sabre-shaped plate, a little twisted on itself. The coracoid is thicker, straighter, and shorter than the scapula; it is rather suddenly expanded at the sternal end, where it is most compressed: the scapular end developes a protuberance below the glenoid cavity.

The scapular arch in *Pterodactylus giganteus*, Bwk., from the Chalk of Kent ('Monog. Cretaceous Reptiles,' 1851, p. 93, Tab. XXXI, fig. 7), was distinguished by a tuberous (acromial) process from the scapula, near the glenoid cavity, the corresponding anterior process from the coracoid being well marked.

The fossil fragment from the Cambridge Green-sand (Tab. III, figs. 1 and 2) consists of the coalesced extremities of the scapula (*a*) and coracoid (*b*), where they form the glenoid cavity for the humerus. The margins of the cavity are in part abraded, but its long diameter cannot have been less than 1 inch 3 lines; it is concave vertically, rather convex transversely below, but plane, or a little concave, in that direction at the upper or scapular end. The cavity is transversed obliquely by a depression pretty equally dividing it, and indicating the respective shares of the scapula and coracoid in its formation prior to the anchylosis of those two bones. The end of the scapula, near the cavity, would present an unequally three-sided figure in transverse section, the side looking inward and that looking forward being concave, the side looking outward convex. Half an inch above the border of the glenoid cavity is the fractured base of the (acromial) process answering to that in *Pterodactylus giganteus*, but which is more feebly developed in *Pterodactylus macronyx*, Bkd., and *Pterodactylus suevicus*, Qnstd. Beyond this process the bone rapidly contracts in size, and presents an oval transverse section, as at *a*, fig. 2, Tab. III.

The surface of the coalesced extremities of the bones which is applied to the thorax is concave in every direction, and an inch in breadth, with a long narrow (pneumatic) aperture near its hinder border. The anterior production of the coracoid has been broken away at *c* (figs. 1 and 2), the coracoid quickly contracts as it recedes from the humeral articulation to a size and shape shown by the section *b* (fig. 2). The size of the entire scapular arch, according to that of *Pterodactylus macronyx*, is shown by the dotted outlines in fig. 1.

Fig. 3 shows the articular surface of the scapular arch of a Pterodactyle of larger size than the preceding specimen; the oblique groove indicative of the portions contributed by the scapula and coracoid to the cavity is well marked, as it also is in the corresponding fragment of the scapular arch of the smaller Pterodactyle (fig. 4). In the still smaller but similar fragment of the scapular arch (fig. 5), the posterior concave surface shows the long (pneumatic?) foramen very distinctly, and also a trace of the primitive separation of the scapula and coracoid. If this specimen has belonged to a young individual of either of the two larger species, it shows that the union of the two bones takes place at an early age. In the bird, although the early

and extensive coalescence of originally distinct bones is a characteristic of the skeleton, the scapula remains distinct from the coracoid, and the persistent suture traverses the glenoid cavity. The coracoid is shorter and straighter in birds than in Pterodactyles, but is commonly broader, and with a longer and stronger anterior process.

Humerus.

The portion of bone figured of the natural size in Tab. III, fig. 7, shows an articular surface of a reniform figure, convex in its shorter diameter, less convex upon the more prominent half, lengthwise, and slightly concave lengthwise at the side which is hollowed out. The smaller end of the surface (*a*) has been produced into a process, here broken away, and the fracture is coextensive with the length, in the direction of the shaft of the bone, of the fragment, which is nearly two inches; the larger end of the articular surface (*b*) seems not to have sent off such a process; but the back part of this end is broken away. The pterosaurian nature of the fragment is shown by the thinness of the compact wall of the shaft below the articular surface, and by the wide cancelli. The general resemblance of the articular surface, in shape, to that of the humerus of the Wealden Pterodactyle (*Pt. sylvestris*, Ow.) figured in the 'Quarterly Journal of the Geological Society,' Dec., 1845, vol. ii, p. 100, fig. 6; and to that of the more complete humerus of *Pterodactylus suevicus*, Qnstd., loc. cit., but especially to the articular surface of the portion of bone of a smaller Pterodactyle (Tab. III, figs. 14 and 15), which exhibits more distinctive characters of a humerus, have led me to refer the fragment in question (fig. 7) to the proximal end or head of that bone in one of the large species above established by maxillary characters.

The end of the articular surface (*a*) answers to the outer plate or process (*g*) in *Pterodactylus sylvestris*, and the fractured surface behind the end (*b*) might well have been the base of a shorter and thicker process, like that marked *f* in *Pter. sylvestris*. Determining, by these analogies, that *a* is the outer or radial, *b* the inner or ulnar, end of the transversely extended head of the humerus; that the convex side is the fore part, and the concave one the back part, of the same bone; it may next be remarked that the inner half of the fore part of the articular surface is extended further and more convexly upon the shaft than the outer half, which meets the vertical plane of the shaft more abruptly; but the form of this part of the head of the humerus is better shown in the next specimen.

This fragment (fig. 8) is the head of the opposite humerus of a Pterodactyle of equal size with the preceding. The boundary of the articular surface near the outer process (*a*) is very slightly raised, with a few short ridges at right angles, indicative of the firm attachment of the capsular ligament; an oblique line divides the

more abruptly defined outer half of the surface from the inner anteriorly more convex half. The anterior surface of the fore part of the shaft of the humerus, here preserved, is impressed by longitudinal reticulate markings. The total length of the humerus, according to the proportions of the length of that bone to the breadth of its proximal articular surface in *Pterodactylus suevicus*,* would be $10\frac{1}{2}$ inches.

Fig. 9 shows well the minutely punctate surface of the articular head of the humerus; the portion of the fore part of the shaft preserved with this shows that the fine reticulate markings are limited to a short distance below the head, and that the rest of the outer surface of the shaft here preserved is smooth. The extent of the base of the outer plate or process is 1 inch, the long diameter of the articular surface of the head being 1 inch 3 lines.

The fragment of the head of the humerus (Tab. III, fig. 10) is remarkable for the well-defined ridge bounding the anterior convex part of the articular surface.

The proximal end of the smaller humerus (fig. 11) includes nearly two inches of the shaft, of which a front view is given in fig. 12, and a back view in fig. 13. The base of the outer process (*g*) shows the same proportion to the long diameter of the head, as in fig. 9. The fractured surface along the opposite side of the shaft (*f*) seems to show that this border had been produced into a ridge or plate, as in *Pterodactylus sylvestris.* The back part of the shaft between these plates is concave transversely, but rather convex lengthwise; the opposite conditions prevail on the fore part of the bone. Here, towards the base of the outer process, is a small, apparently pneumatic, oblong foramen.

The smaller proximal end of humerus (figs. 14 and 15), shows a larger proportion of the process (*f*) which extends the bone in that direction beyond the articular head.

All these specimens show that, in the Pterodactyles from the Green-sand, there is a plate or process with a shorter base, extending close to the articular surface of the head of the bone, and that there is a plate, with a larger base, extending farther from the articular head at the opposite side of the bone.

The fragment (figs. 1, 2, and 3, Tab. IV) shows part of the articular extremity of one of the long bones of the wing. The articular surface has been partially divided into what might be called, were they entire, two condyles (*a* and *b*). The most perfect of these divisions shows a slightly convex surface (figs. 1, and 2, *a*, *a*,) occupying its major part, and a small well-defined flat surface (figs. 1, and 3, *c*,), placed obliquely. So much of the other division as is preserved likewise shows two facts

* See the plate in Quenstedt's 'Memoir,' above cited.

one, which we may call the anterior (*d*), is convex and of small extent, and behind it is a well-defined part of a concave surface (*b*). At the fore (?) part of the bone (fig. 2) the two convex surfaces extend a little upon the shaft (*a*), and are divided from each other by a moderate median depression; where the thin smooth outer crust of bone has been worn away, the small superficial cancelli are exposed. At the back (?) part (fig. 3), where the major part of the bone is broken away, the larger cancelli are exposed.

Guided by considerations of size, the fragment (Tab. IV, figs. 1—3) might form the opposite end of the bone indicated by the articular ends (Tab. III, figs. 7, and 8). I am not acquainted with the precise configuration of the distal end of the humerus, in any Pterodactyle; indeed, the articular surfaces of very few of the bones of this remarkable reptile have been perfectly preserved, so as to be recognisably delineated and described. From general analogy, however, one should scarcely be prepared to find so feeble an indication of divisions into condyles, an absence of general convexity, and a presence of a well-defined concavity in one condyle, and as well-defined a flattened or feebly concave facet in the other condyle, of the distal end of a humerus. The form of articulation above described would seem rather to be that of the end of an antibrachial bone adapted to join the bones of a carpus. But, on the hypothesis of the fragment in question being either proximal or distal, and of a radius or ulna, it expands our ideas of the bulk of the Green-sand Pterodactyle even beyond those suggested by the manifestly head of the humerus (Tab. III, fig. 7). The present description and figures will at least help, it is hoped, to forward a precise knowledge of the osteological characters of the *Pterosaurians.*

Assuming that we have in figs. 1—3, Tab. IV, the articular end of an antibrachial bone, then, according to the proportion which the broadest end of one of these bones bears to its total length in the *Pterodactylus suevicus*, the length of such antibrachial bone in the great Pterodactyle of the Green-sand here indicated would be 16 inches. The total length of wing will be calculated on this basis at the conclusion of the present Monograph.

The fifth or wing-metacarpal.

The trochlear joint of the bone (Tab. IV, figs. 9—11) belongs to the distal end of the metacarpal of the fifth or wing-finger. The pulley is more complex, in the large Pterodactyles here described, than it is in similar trochlear joints of other animals; there are three convex ridges, *a*, *b*, *c*, which traverse the articular surface from behind forward, describing rather more than half a circle; the middle ridge, *c*, is less prominent, and of less extent than the lateral ones which form the sides of the pulley. The direction of the ridges is rather oblique, and one which, to help the description, may be called

the outer ridge, is rather more produced and of a less regular curve than the inner ridge. The outer ridge, *a*, begins by a rising at the middle of the fore part of the distal end of the shaft, which bends obliquely outward and meets the outer angle of that part of the shaft where the outer trochlear ridge begins to be prominent; this ridge then extends with a feeble convex curve to the back part of the trochlea, where the convexity of the curve increases, and it terminates by projecting a little beyond the level of the outer almost flattened side of the trochlea (fig. 10). The articular surface, as it extends from the margin of this element of the trochlea inward, is first gently convex, then sinks to a concave channel by the side of the low median convexity. The inner ridge *b*, begins from the inner side of the fore part of the bone, and describes a pretty regular semicircular curve as it extends backward and a little outward, to terminate near the middle of the back part of the distal end of the shaft; thus owing to the termination of the inner ridge near the middle of the back part, and to the beginning of the outer ridge near the middle of the fore part, of the metacarpal bone, these principal ridges of the trochlear joint recede from each other at the middle of the joint, and approximate at the fore and back ends of the joint. As the back ends of the two lateral ridges are on the same transverse line, and the front end of the inner ridge rises higher upon the shaft than that of the outer ridge, this is by so much the shorter of the two. The low middle ridge *c*, is much shorter than either of the lateral ones, being confined to the lower and middle part of the trochlea, to which it gives an undulating transverse outline (fig. 11).

The figure of the metarcarpal bone of the wing-finger, in *Pterodactylus suevicus*, Qnstd., does not show any trace of the mid-rising of the distal trochlear joint. The back surface of that of the left wing shows a wide and moderately deep excavation along the upper three fourths of the shaft. A portion of a similarly shaped shaft of a long bone, in size matching that of the trochlear extremity (fig. 10), is represented in Tab. IV, figs. 4 and 5. Although both ends are broken away, yet the degree of expansion toward the upper end shows that this was not very far from the proximal articulation. The shaft is three-sided; two of the sides are nearly flat or very feebly convex; they meet anteriorly at an acute angle, but this is rounded off as shown in the transverse sections of figs. 4 and 5; the third and shorter side is concave in the degree shown in the same sections. The lower of these (fig. 5), indicates the extreme thinness of the compact wall of the bone, and the size of the cancelli occupying that part of the shaft.

The portions of the wing-bones of the Pterodactyles of the Cambridge Greensand, here described and figured, show the same superior proportions over those of the great Pterodactyles from the Kentish Chalk, described and figured in a former Monograph, 4to., 1851, as do the portions of jaw bones and teeth.

The long diameter of the largest of the wing-bones, figured in Tab. XXX, fig. 1,

4to, 1851, *e.g.*, is 2 inches 2 lines; that of the wing-bone, figured in Tab. IV, figs. 1—3 of the present Monograph, is 3 inches. The transverse diameter of the distal end of the humerus of ***Pterodactylus grandis,*** Cuv., the largest species hitherto obtained from the Lithographic Slates of Germany, is 1 inch 3 lines; neither the radius, ulna, nor metacarpal of the wing-bone of the same species presents a diameter of its largest end equalling 1 inch.*

The articular end of the long wing-bone (Tab. IV, figs. 1—3), being most probably that of an antibrachial bone, and the total length of the bone, whether radius or ulna, being, according to proportions of either of these bones in ***Pterodactylus suevicus,*** 16 inches, the following would be the length of the other long bones of the wing in the large Pterodactyle to which the above-cited specimen belonged, according to the proportions which those bones bear to the radius or ulna in ***Pterodactylus suevicus:***

	Ft.	In.	Lines.
Humerus	1	0	0
Radius	1	4	0
Metacarpus of wing-finger	1	8	0
First phalanx of do.	2	3	0
Second do. do.	1	9	0
Third do. do.	1	5	0
Fourth do. do.	1	1	0
Total length of long-bones of one wing	10	6	0

Supposing the breadth of the Pterodactyle between the two shoulder-joints to be 8 inches, and allowing 2 inches for the carpus and the cartilages of the joints of the different bones, in each wing, we may then calculate that a large *Pterodactylus Sedgwickii* would be upborne on an expanse of wings of not less than 22 feet from tip to tip.

I look forward with confidence to future acquisitions of remains of the truly gigantic Pterodactyles of the cretaceous periods, more especially from the Greensand locality, near Cambridge, as a means of throwing more light on the peculiar osteology of the extinct flying reptiles.

For the opportunities at present afforded me, I have to express most grateful acknowledgments to my old and much esteemed friend the Rev. Professor Sedgwick, F.R.S.; to the acute and active curator of the Woodwardian Museum, Mr. Lucas Barrett, F.G.S.; to James Carter, Esq., M.R.C.S., Cambridge; to T. W. Beddome, Esq., of Trinity College, Cambridge; and to the Rev. G. D. Liveing, M.A., of St. John's College, Cambridge, to whom I am indebted for the lower jaw of *Pterodactylus Sedgwickii* (Tab. I, figs. 2, *a, b, c, d*).

* These admeasurements are derived from the excellent figures of a recently acquired specimen, well described by Professor Andreas Wagner of Munich, in the "Abhandlungen der Kais. Bayer. Akademie der Wissenschaft," Band iii, p. 663, taf. xix.

TAB. I.

Genus *Pterodactylus.*

Fig.

1. Fore part of the upper jaw of *Pterodactylus Sedgwickii: a*, side view; *b*, under view, or palatal surface; *c*, front view or end; *d*, section of fractured opposite end.
2. Fore part of the lower jaw of *Pterodactylus Sedgwickii: x*, side view; *b*, upper view; *c*, section of fractured end; *d*, one of the sockets, magnified, showing the protruding apex of a young successional tooth.
3. Fore part of the upper jaw of *Pterodactylus Fittoni: a*, side view; *b*, under view; *c*, section of fractured end.
4. Another portion of the upper jaw of *Pterodactylus Fittoni: a*, side view; *b*, section.
5. A fragment of the upper jaw with one socket of *Pterodactylus Fittoni: a*, under view; *b*, outside view; *c*, inside view, showing the large cancelli.
6. A fragment of the upper jaw of a large *Pterodactylus Sedgwickii: a*, under view; *b*, end view, showing the deep implantation of the tooth; *c*, outside view.
7. Part of the under jaw of *Pterodactylus Sedgwickii: a*, side view; *b*, upper view, or that next the mouth; *c*, under view; *d*, section.
8. Base of a tooth, impressed by the apex of a successional tooth, at *o*.
9. Crown of a tooth.
10. Base of a large tooth, showing the longitudinally wrinkled cement.
11. Anchylosed atlas and axis: *c*, centrum of atlas; *cx*, centrum of axis; *b*, articular ball of axis; *p*, inferior process; *o*, pneumatic foramen; *n*, neurapophysis of atlas; *nx*, neural arch of axis; *z*, posterior zygapophysis and tubercle of axis.
12. Section of anchylosed atlas and axis: *h*, median hypapophysis.
13. Front view of the axis vertebra from which the atlas has been detached.
14. Back view of the same vertebra.

All the foregoing figures are of the natural size, and from specimens in the Woodwardian Museum of the University of Cambridge (with the exception of fig. 7 in the Private Collection of the Rev. G. D. Liveing, M.A., of St. John's College, Cambridge); they were obtained from the Upper Geen-sand (Neocomian), near that town.


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TAB. II.

Vertebræ of *Pterodactylus Sedgwickii* and *Pter. Fittoni.*

Fig.

1. Front view of anchylosed atlas and axis.
2. Back view of the same.
3. Side view of the same.
4. Under view of the same: *a*, anterior tubercle, or rudiment of zygapophysis, of axis; *z*, posterior zygapophysis, of axis; *c*, centrum of atlas; *p*, infero-posterior processes of axis; *b*, articular ball of axis.
5. Front view of a larger specimen of atlas and axis.
6. Under view of the same, indicative of a species distinct from fig. 4.

7. Side view, 8. Back view, 9. Upper view, 10. Front view, 11. Under view — of a middle cervical vertebra.

12. Under view, 13. Side view — of a cervical vertebra.

14. Upper view, 15. Side view, 16. Under view — of a cervical vertebra.

17. Upper view, 18. Under view — of a more complete cervical vertebra.

19. Section of a large cervical vertebra.

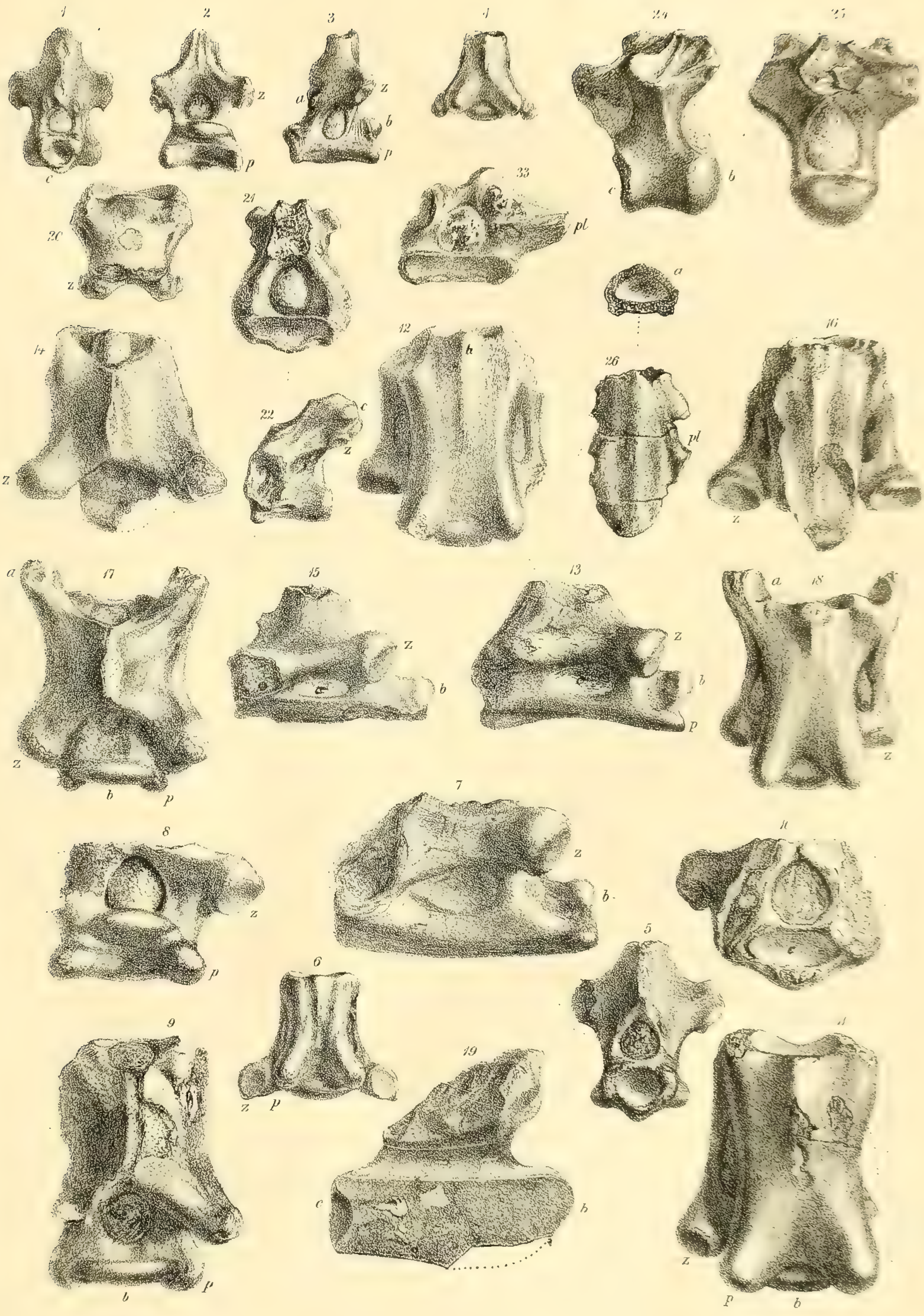
20. Under view, 21. Front view, 22. Side view — of an anterior dorsal vertebra.

23. Front view of a lumbar vertebra.

24. Side view, 25. Back view — of a dorsal vertebra.

26. Under view of three anchylosed sacral vertebræ.

All the figures are of the natural size, and from specimens in the Woodwardian Museum of the University of Cambridge, which were found in the Upper Green-sand (Neocomian) near that town.



Jos Dinkel lith

W West imp

TAB. III.

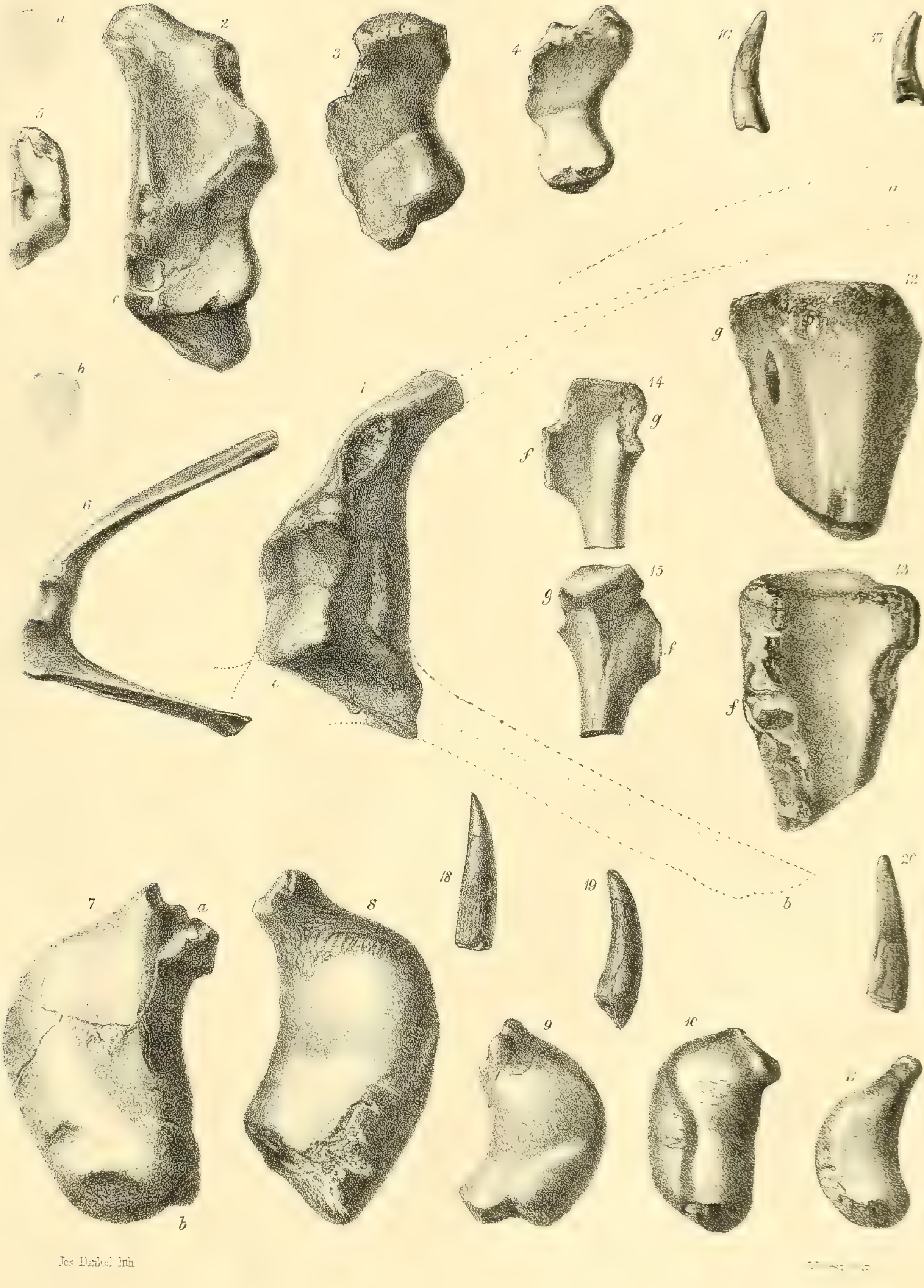
Pterodactylus Sedgwickii and *Pterodactylus Fittoni.*

Fig.

1. Humeral end of anchylosed scapula *a*, and coracoid *b*, with the glenoid articular cavity. The letter *c* indicates the base of the broken-off anterior or angular production of the coracoid.
2. Front view of the same specimen.
3. Similar view of the glenoid articular cavity of a similar sized Pterodactyle.
4. Glenoid articular cavity of a smaller specimen, and probably different species.
5. Inner surface of the anchylosed humeral end of the scapula and coracoid of a still smaller Pterodactyle.
6. The scapulo-coracoid arch of *Pterodactylus* (*Dimorphodon*) *macronyx*, Bkd.
7. The articular head of the right humerus of a large Pterodactyle.
8. The articular head of the left humerus of a large Pterodactyle.
9. The articular head of the left humerus of a smaller Pterodactyle.
10. The articular head of the right humerus of a similar sized Pterodactyle.
11. The articular head
12. (The convex side) } of the proximal end of the humerus of a Pterodactyle.
13. (The concave side)
14. (The convex side) } of the proximal end of the humerus of a smaller Pterodactyle.
15. (The concave side)

16—20. Different teeth of Pterodactyles.

All the figures are of the natural size, and from specimens in the Woodwardian Museum of the University of Cambridge, which were found in the Upper Green-sand (Neocomian) near that town.



Jos Dinkel lith.

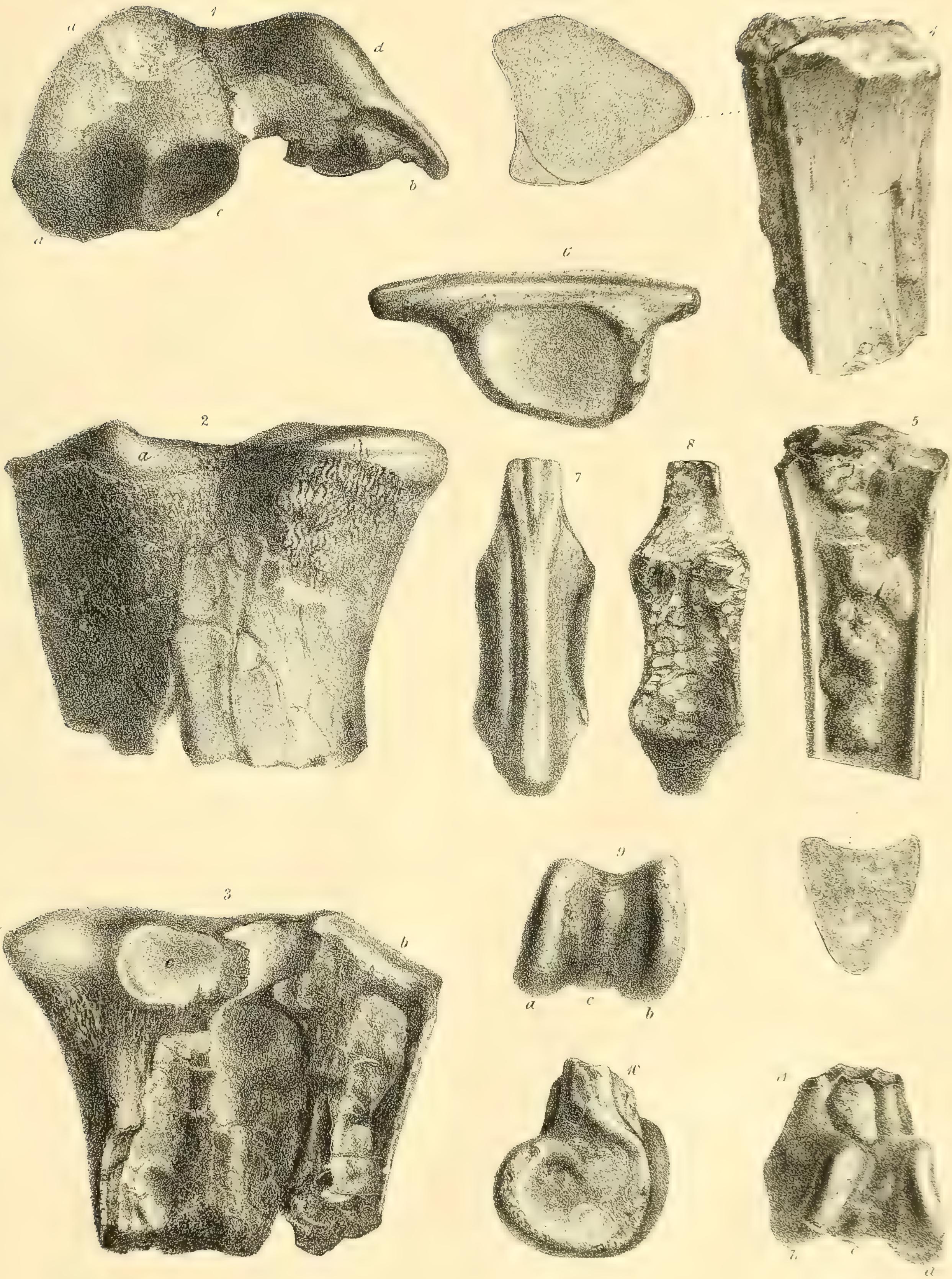
TAB. IV.

Pterodactylus Sedgwickii and *Pter. Fittoni.*

Fig.

1. Articular end,
2. Front (?) surface } of a long bone of the wing.
3. Back (?) fractured) surface } of a long bone of the wing.
4. Side view } of part of the proximal end of the metacarpal of the 5th or wing-finger.
5. Back (?) view } of part of the proximal end of the metacarpal of the 5th or wing-finger.
6. Side view
7. Upper (?) view } of a symmetrical (probably frontal) bone.
8. Opposite fractured surface } of a symmetrical (probably frontal) bone.
9. Articular end } of the trochlear distal extremity of the metacarpal of the 5th or wing-finger.
10. Side view } of the trochlear distal extremity of the metacarpal of the 5th or wing-finger.
11. Back view } of the trochlear distal extremity of the metacarpal of the 5th or wing-finger.

All the figures are of the natural size, and from specimens in the Woodwardian Museum of the University of Cambridge, which were found in the Upper Green-sand (Neocomian) near that town.



Jos. Dinkel lith.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

SUPPLEMENT No. II.

PAGES 27—30; PLATE VII.

DINOSAURIA (IGUANODON).

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1861.

SUPPLEMENT (No. II)*

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE CRETACEOUS FORMATIONS.

ORDER—DINOSAURIA, *Owen.*

Genus—IGUANODON, *Mantell.*

Dentition of the Upper and Lower Jaws (Tab. VII).

In the year 1858 a considerable part of the skeleton of an Iguanodon was discovered in the Lower Greensand formation at Black Gang Chine, Isle of Wight.

The workmen disposed of various parts of it, as opportunities offered; and before steps could be taken to secure the whole for the British Museum, portions of jaws and teeth had passed into the hands of private collectors. From the best account of the discovery that I could collect, it appeared that the entire cranium, somewhat dislocated, had been brought to light by the quarrymen; but the bones were in a peculiarly fragile, crumbly state, and only the firmer parts of the jaws, lodging the teeth, were secured, and these portions in fragments. Some of them, of both upper and lower jaws, are now in the British Museum; and learning that other portions had been acquired by George Robbins, Esq., F.G.S., of Castle, near Bath, I addressed a letter to that gentleman, who very kindly brought his specimens to London, and liberally placed them in my hands for description. The largest fragment fitted on to another portion of the jaw in the British Museum, adding to its value as an illustration of the most interesting of the hard parts of the Iguanodon. It consisted of a fragment of the left upper jaw, with three teeth; there were also three fragments of the left ramus of the lower jaw, with one or more teeth in each.

The germs of the new teeth are developed, in all Saurians, as is well known, on the inner or mesial side of the base of the old teeth.† One of the teeth in the

* This Memoir was given as "Supplement (No. II) to the Monograph on the Iguanodon," in the 1858 volume.

† Of this character Professor Melville ably availed himself in determining the upper and lower teeth of the Iguanodon, in the joint memoir, by Dr. Mantell and himself, in the 'Philos. Trans.' for 1848.

portion of the upper jaw (Tab. VII, figs. 1, 2, and 3, *m*) has its summit obliquely worn from above downward and outward to the enamelled trenchant border ; the contiguous tooth, *n*, the summit of which has not suffered abrasion, is pressing upon the smooth, concave side of the older tooth; a third tooth, *o*, the crown of which is still buried in the alveolus, has the same relation to the more advanced tooth, *n*. The smooth, concave sides of these teeth, shown in fig. 1, are, therefore, the inner or mesial ones, and the flat surface of bone extending from the alveolar border is the inner or palatal alveolar wall of the maxillary bone.

The crown of each tooth shows that more definite and prominent primary ridge on their outer side (*a*, figs. 2, 3, and 4) which is characteristic of the teeth of the upper jaw of the Iguanodon.

In figs. 5 and 6, three of the teeth (*m*, *n*, *o*) show precisely the same stages of growth as the foregoing one; one (*m*) has the summit abraded from the enamelled trenchant border downward and outward; in a second (*n*) the crown is extricated, but not worn; in a third (*o*) the major part of the crown is still in the formative cell. The relative position of these three teeth to each other is, in one respect, the reverse of those in fig. 1. The convex ridge side of the crown of the second tooth (fig. 5, *n*) partly overlaps (instead of being overlapped by) that of the first (*m*), and it is similarly overlapped by the germ of the third (*o*). The side of the jaw to which the newer teeth (*a r*, fig. 5) are nearest is the inner one; the smooth, longitudinally concave, side of the tooth is next the outer side of the jaw (fig. 6); they belong to the lower jaw, and they show the formal characters of mandibular teeth; the primary ridge, *a*, is less produced.

The upper teeth (figs. 1—4) are narrower, in the direction of the length of the jaw, or from *c* to *d*, and are less curved than the lower; the fang and base of the crown are thicker, transversely to the jaw or from *a* to *g* (fig. 4). The primary ridge, *a*, is more prominent; the secondary ridges, *b*, are less constant and less marked than in the lower teeth. Both fore (*c*) and hind (*d*) borders at the base of the crown are entire, and are bent or produced slightly outward, bounding the transversely concave areæ between them and the primary ridge; they slightly diverge as the crown expands; along its apical half both borders are serrate or serro-lamellate, converge, and, with a slight difference of contour, meet at the apex of the unworn crown formed by the termination of the primary ridge (*n o*, fig. 2). This ridge, *a*, commencing in a tooth $3\frac{1}{2}$ inches long about 1 inch 8 lines from the base, becomes thinner and sharper as it projects, which is to the greatest degree before it reaches the middle of the crown, whence it gradually subsides to the apex; its longitudinal profile is a slight curve convex outward: this ridge divides the outer side of the crown unequally, the front area, *a*, *c*, being broader, sometimes nearly twice the extent of the hind one, *a*, *d*. The dentated margin of the crown to which the primary ridge is the nearest is the posterior one, and is

the shortest and straightest (fig. 2, *d*). A few, irregular, linear, minute, ridges mark the enamel in both areæ; being more numerous, from three to five, in the wider one, and not more than one or two of these extend from the base to the apex of the crown; at the base they converge and sometimes unite as they descend.

The fore part of the tooth is slightly hollowed at the basal half of the crown (fig. 4, *e*); the fossa, which is elongated and concave transversely, gradually filling up towards the apex; below the middle of the crown, at the apical half, the fore part of the crown (fig 1, *e*) is convex transversely. The hind part of the tooth (fig. 4, *f*) is impressed by a longer, wider, and shallower depression, beyond which it shows an oblique, rather flattened than convex, surface. The inner part of the tooth, which is narrow in the fang (fig. 4, *g*), gradually expands upon the crown to near the apex, where it again grows narrower; at its broadest part it is flattened or even a little concave transversely, but rounds off convexly into the fore and hind parts of the crown (fig. 1, *m*).

The abraded surface of the crown is remarkably smooth and level; it inclines from before downward and backward, and more so from within downward and outward in the upper jaw.

The longitudinally convex and ridged part of the crown being external in the upper teeth, and the position of the primary ridge determining the fore and hind borders of the crown, a detached tooth may be at once referred to the right or left maxillary bone. The germ of the successional tooth causes an excavation on the inner, and generally towards the hinder, part of the base of the one in use.

In a left upper tooth, with one fourth of the crown abraded, and projecting 1 inch 9 lines from the alveolar border, the crown of the successional tooth had its apex on a level with that border, and on the inner and back part of this crown was the thin shell of the apex of a third tooth in the successive series.

The outer alveolar wall of the upper jaw is very thin at the outlet of the sockets, and is a little produced at the intervals of the teeth; it rapidly increases in thickness towards the base of the sockets.

The inner or palatal wall also thins off to a crenate edge; so much as is preserved in the specimens examined was flat and smooth, as in fig. 1. The grinding surface of the tooth (*m*), of which one third of the apex had been worn away by mastication, projected only about half an inch from the inner alveolar margin.

The lower or mandibular teeth of Iguanodon have a broader crown, and a fang less thick transversely to the jaw than the upper teeth; they are more curved lengthwise, the curvature being concave outward, contrary to that of the upper teeth. The outer side of the tooth (fig. 6, *m*, and fig. 11, *o*) is smooth and convex from the fore (*c*) to the hind (*d*) border, its greatest breadth being opposite the middle of the crown. The primary ridge, commencing at the enamelled base of the inner and flatter part of the crown (fig. 5, *m*, *a*, and fig. 11, *a*), slowly rises, and

is most marked along the apical half, but is here much less prominent than in the upper teeth; it divides the crown into two unequal areæ, the front one (fig. 5, *m, a, c*) being at its broadest part nearly twice the breadth of the back one (ib., *a, d*). The front area is pretty equally subdivided by a low, secondary, longitudinal ridge, *b*, each division being feebly concave across. The angle between the entire (fig. 11, *i*) and serrated (fig. 11 *c*,) parts of the borders of the crown is more marked than in the upper teeth; the basal part of the posterior border (fig. 11, *d*) seems as if it were pushed inward and forward by the crown of the succeeding and less developed tooth. The anterior serrated border (fig. 5, *n, c*) is at first straight, then describes a bold, convex curve as it approaches the apex. The posterior border (ib., *d*) passes almost to that apex in a straight line before it is rounded off to the obtuse summit, where the primary ridge terminates. At the fore part of the tooth (fig. 9) the fang is convex, and the basal half of the crown shows a lanceolate depression, slightly concave across. The back part of the tooth (fig. 8) shows a longer, shallow depression, *s*, extending over the upper half of the fang and lower third of the crown. The inner or longitudinally convex side of the narrow fang, in worn teeth, is sharply excavated, even to expose the pulp-cavity, by the crown of the successional tooth (figs. 13 and 14, *p*).

The apex of the crown of a young successional tooth is shown at *r*, on the inner side of the tooth *p* in fig. 5. The remnant of the fang and alveolar depressions of the old and shed teeth are shown at *t*, *t*, on the outer side of the succeeding teeth, in fig. 7. Both are from the lower jaw.

The upper part of the outer alveolar wall of the mandible bends out, so as to be concave vertically; its border is more deeply crenate than in the upper jaw. A vascular canal runs about an inch and a half beneath it, from the oblique orifices open upon the outer surface of the mandible.

Figs. 10—14, in Tab. VII, from the dental series of the same individual, discovered in the Greensand of Black Gang Chine, exemplify different degrees of destruction of the tooth by abrasion and absorption. Fig. 10 is an unworn tooth from the fore part of the lower jaw. Figs. 11—14 show the size of the majority of the teeth. In figs. 13, 14 the letter *p* marks the cavity caused by pressure of the new or successional tooth; in fig. 14 it has laid open the pulp-cavity of the old tooth.

Fig. 15 shows the inner side, and fig. 16 the fore part, of a mandibular tooth of a young Iguanodon, from the Upper Greensand near Cambridge. The inner side of the fang shows the excavation due to the pressure of the successional tooth (*p*, fig. 15). Fig 17 shows the outer and inner sides of a smaller tooth of an Iguanodon, from the same formation and locality. All the evidences of Iguanodon which have yet reached me therefrom indicate a small size; but whether this may relate to the immaturity of the individual, or to a small variety, I am uncertain.

TAB. VII.

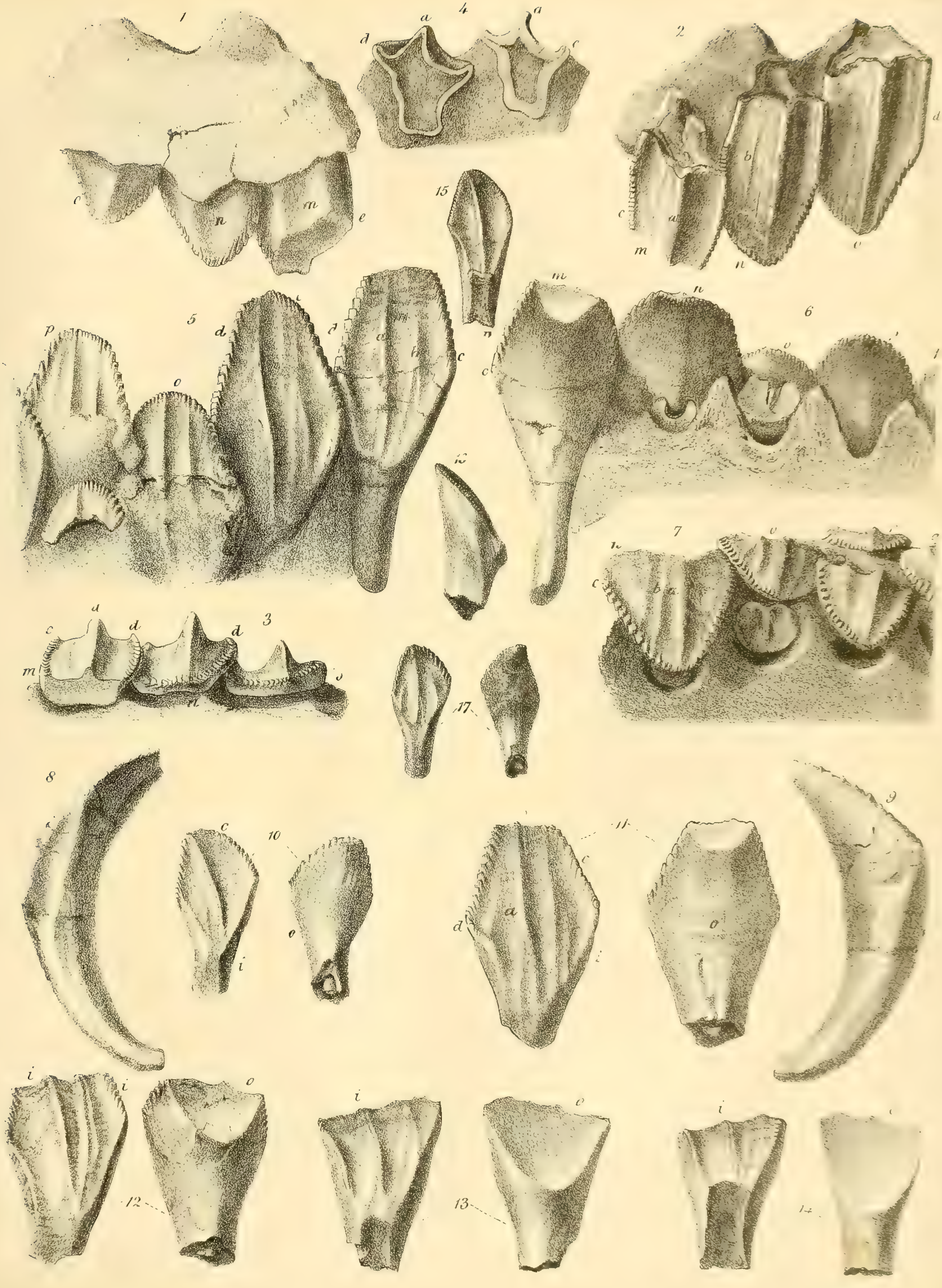
Iguanodon Mantelli.

Fig.

1. Fragment of the left upper jaw, with three teeth, inner side.
2. Ditto, outer side.
3. Ditto, free or working surface of the crowns of the teeth.
4. Fragment of the upper jaw, with two teeth, showing their transverse section.
5. Fragment of the left ramus of the lower jaw, with four teeth, inner side.
6. Ditto, outer side.
7. Ditto, upper view.
8. A lower tooth, back surface.
9. Ditto, front surface.
10. An unworn lower tooth; *i*, inner, *o*, outer surfaces.
11. A lower tooth, slightly worn; *i*, inner, *o*, outer surfaces.
12. A lower tooth, more worn; *i*, inner, *o*, outer surfaces.
13. A lower tooth, more worn; *i*, inner, *o*, outer surfaces.
14. A lower tooth, worn to the fang; *i*, inner, *o*, outer surfaces.

All the foregoing figures are of the natural size, from parts of the same individual Iguanodon, discovered in the Lower Green-sand formation at Blackgang Chine, Isle of Wight. In the British Museum, and in the Collection of George Robbins, Esq., V.G.S., of Bath. Figs. 15, 16, and 17, are from the Upper Green-sand formation near Cambridge.

T. VII.



MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

SUPPLEMENT No. III.

PAGES 1—25; PLATES I—VI.

PTEROSAURIA (PTERODACTYLUS)

AND

SAUROPTERYGIA (POLYPTYCHODON).

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1861.

SUPPLEMENT (N°. III)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE CRETACEOUS FORMATIONS.

ORDER—*PTEROSAURIA*, *Owen*.

Genus—PTERODACTYLUS, *Cuvier*.

IN former monographs on the fossil reptilia of the Upper Green-sand of Cambridgeshire,* I have described, figured, or referred to, parts of a Pterodactyle, from an individual surpassing in size that to which the portions of upper and lower jaw† belonged on which the species dedicated to Professor Sedgwick was founded. Such fossil evidences of more gigantic flying reptiles, showing no better distinctive characters, were deemed, probably, to belong to the *Pterodactylus Sedgwickii*,‡ the then largest known species of the genus.

I am now, however, enabled to adduce, from the more recently acquired additions to the Woodwardian Museum at Cambridge, supplied to me by the same unfailing liberality of the eloquent Professor, evidences of a much larger Pterodactyle, distinct, in regard to the form of the skull, from any previously known, and one which, assuming that the portion of upper jaw of *Pterodactylus Sedgwickii* (Tab. I, fig. 1, 'Monograph' of 1857) belonged to a full-grown specimen, must have acquired at least double the dimensions of that species.

* 'Monograph on Fossil Reptilia of the Cretaceous Formations' (1857), tab. i, p. 6; tab. iv, figs. 1, 2, and 3.

† Ibid., t. i, figs. 1 and 2.

‡ Ibid., p. 5.

PTERODACTYLUS SIMUS, *Owen.*

Jaws and teeth (Tab. I, figs. 1—10).

The first evidence I have to offer of this truly gigantic flying reptile consists of the corresponding part of the upper jaw with that on which the *Pterodactylus Sedgwickii* was founded, viz., the anterior extremity forming the muzzle (Tab. I, figs. 1—5), including the first four (*a, b, c, d*) and part of the fifth (*e*) sockets of the teeth. The comparison and appreciation of the specific distinctions of the two large Pterodactyles are thus rendered easy and satisfactory.

In the specimen of *Pterodactylus simus* (Tab. I, figs. 1—5), the first tooth (*a*) on the left side remains in the socket; it is not larger than the corresponding tooth in *Pterodactylus Sedgwickii*, and, consequently, is relatively much smaller than in that species. Its socket and that of its fellow, moreover, are differently situated, opening downwards, like the succeeding sockets, and the position of the exserted foremost tooth is accordingly vertical and nearly parallel with the lower half of the anterior contour of the muzzle. In *Pterodactylus Sedgwickii*, the sockets of the first pair of teeth open upon the forepart of the muzzle, and look almost directly forward,* and their teeth had, consequently, a nearly similar direction; the same, viz., which they appear to have had in *Pterodactylus suevicus*, Qnst.†

The contour of the muzzle in *Pterodactylus Sedgwickii* rises at first vertically above these sockets before curving back into the upper part of the skull's profile, and gives an obtuse anterior termination to the upper jaw;‡ but this character is much exaggerated in the present specimen (Tab. I, figs. 1 and 3), not only by the greater relative extent of the vertical part above the front sockets, but by the greater breadth of that part, which is flattened anteriorly, forming a surface (fig. 3) of nearly 2 inches in length, about 10 lines in breadth below, and contracting gradually above to a point, where the blunt ridge begins that forms the upper part of the profile of this portion of the skull. The name proposed for the species refers to this peculiarly obtuse and flattened forepart of the cranium. In *Pterodactylus Sedgwickii*, the upper ridge of the forepart of the cranium is continued down to between the first pair of sockets,§ the muzzle being only obtuse vertically, and not transversely, as in *Pterodactylus simus*.

The flattened anterior surface, in the specimen figured (Tab. I, fig. 3), is im-

* 'Monograph' for 1857, tab. i, fig 1, *c*.

† 'Ueber *Pterodactylus suevicus*,' &c., 4to, 1855, tab. i.

‡ 'Monograph' for 1857, p. 2, tab. i, fig. 1.

§ Ib., tab. i, fig. 2.

pressed by a very shallow and wide, longitudinal or vertical channel; but this is scarcely marked in a second specimen of a muzzle of the same species. In both specimens the outer surface of the flattened part is less smooth than at the sides of the muzzle, being impressed by numerous irregular, linear grooves, seemingly vascular, affecting the vertical direction at the upper part, and the transverse direction at the rest of the surface.

The ridge where the two sides of the muzzle meet, above and beyond the flattened surface, is more obtuse and is relatively thicker than in *Pterodactylus Sedgwickii.* Were the same curve to be continued from the part of the ridge preserved until it became horizontal, the vertical diameter of the skull at this part would be not less than three inches; it may, however, have risen to a greater height, for the contour is not regularly curved, but sub-angular, as shown in figs. 1 and 2.

The facial part of the skull must have been narrow in proportion to its height, and, no doubt, also to its length. The broadest part of the present fragment does not exceed one inch and a quarter at the fourth pair of sockets; the adherent matrix (*m, m,* figs. 4 and 5) gives a seeming greater breadth to this part of the skull.

The sockets of the first pair of teeth (*a*) are three lines apart, the interspace equalling the largest diameter of the socket; the bone forming this anterior termination of the palate projects as a convexity below the level of the alveolar openings, the plane of which is a little inclined outwards. This inclination is increased in those of the second pair of sockets, which are nearly double the size of the first, and are five lines apart. The second is separated from the first socket by an interval of two lines; its outlet has a full, oval form. The third socket is four lines distant from the second, and exhibits the same ratio of increase of size; there is a shallow, vertical depression on the outer alveolar wall, between the second and third tooth, the socket of the latter appearing to have made a slight prominence on that part of the jaw. The palate at the interspace between the second and third pairs of sockets is flat, showing no trace of the median ridge characterising that part of the upper jaw, or of the groove at the corresponding part of the lower jaw, in the *Pterodactylus Sedgwickii.*

The upper jaw of the *Pterodactylus simus*, in the present specimen, has been partially fractured across the third pair of sockets (figs. 1, 2, 5, *c*), of which only the forepart of the left one is here preserved, showing well-marked vascular grooves. Its outlet, from this fracture, appears to be of a larger oval or ellipse than in the second socket.

The fourth socket (*d*) is preserved only on the right side, with about the right half of the corresponding part of the bony palate. The outlet of this socket resembles in shape and size that of the second; it is three lines distant from the third socket.

The fifth socket (*e*), the forepart of which is preserved on the right side, is four lines distant from the fourth.

The thinness of the compact outer wall of this fragment of the upper jaw, and the large size of the cancelli, concur with the dental characters in demonstrating the Pterosaurian nature of the fossil. So far as the outer wall is preserved, it shows no trace of the external nostril at a distance, viz., of three inches from the forepart of the upper jaw.

The tooth in place is sub-compressed, conical, long, and slightly curved, with the convexity forward. The portion of enamel preserved on the crown accords with the Pterosaurian type of tooth in its thinness, in the very delicate, irregularly wavy, sometimes branching, longitudinal ridges, on its outer surface; the dentine is compact, and is coated by cement at the base of the tooth.

PTERODACTYLUS WOODWARDI. Tab. II, figs. 3, *a*, *b*, *c*.

The specimen from Professor Sedgwick's collection, represented of the natural size in Tab. II, fig. 3, *a*, *b*, is a transverse fragment of the jaw of a Pterodactyle, from the Upper Green-sand of Cambridgeshire, showing a greater divergence of the side walls towards the alveolar or oral surface, and, consequently, greater breadth of that surface in proportion to the height or vertical extent of the part. Of the oral surface too small a portion is preserved to indicate whether it be palatal or mandibular. By the characters of the median ridge or groove pointed out in my former monograph, I incline to regard it as part of the upper jaw, corresponding in the proportions of height and palatal breadth with that of the *Pterodactylus Fittoni* (Tab. I, fig. 3, *c*, 'Monograph' for 1857), but coming from a part of the jaw further from the anterior extremity.

The fractured ends show the characteristic thinness of the compact, bony wall, and the large (air-?) cells occupying its substance.

The side wall, which is most entire, has been abraded (Tab. II, fig. 3, *b*), but the small portions of the preserved surface exhibit the smooth character of Pterosaurian bone. The fragment includes a pair of sockets, with the bases of their teeth. The latter show the usual elliptical, transverse section (fig. 3, *c*). The implanted base of the tooth extends three fourths of the way to the upper border of the jaw; it has a coat of cement half a line thick, with the outer surface longitudinally ridged, corresponding with the grooves of the socket. The direction of the socket shows that the tooth extended obliquely forwards and outwards as well as downwards.

Tab. IV, fig. 4, shows the part of the base and basal half of the crown of a tooth of a Pterodactyle, from the Upper Green-sand of Cambridgeshire, a little surpassing in size that of which the base is shown implanted in the socket of the

portion of jaw (Tab. II, fig. 3), and of that figured in Tab. I, fig. 6, *a, b, c,* of my former 'Supplement' (1857). The total length of the tooth (fig. 4) cannot have been less than 4 inches.

If the present fragment has belonged to an individual of the same species as that on the upper jaw of which the *Pterodactylus Fittoni* is founded, it shows such species to have attained more than double the dimensions indicated by the original specimens figured in Tab. I, figs. 3 and 4, of the 'Monograph' for 1857. Should the present fragment prove to belong to a distinct species, with the sides of the jaw meeting above, at a less acute angle, and with the wall of the outlet of the socket less prominent externally, such species may be indicated as the *Pterodactylus Woodwardi,* in honour of the founder of the Geological Collection of the University of Cambridge.

The mandible (Tab. I, figs. 6—10).

The portion of the right ramus of a lower jaw, or mandible, figured in the above-cited plate, may have belonged, by its size, to either of the gigantic Pterodactyles above specified as *Pt. simus* and *Pt. Woodwardi.* Its texture and configuration show it to have formed part of a Pterosaurian skeleton. It is the part of the ramus which answers to the angular, sur-angular, and articular elements in the *Pterodactylus suevicus,** but with only a part of the sutures between the angular and sur-angular remaining on the inner side of the bone. The angle is partially fractured, but seems to have been not much produced beyond the articular concavity.

The ramus, as it extends forward from the articular part, at first diminishes slightly in breadth and depth, then increases in vertical, whilst continuing to decrease in transverse, extent.

The outer surface (fig. 7) presents, near the articular cavity, a shallow, longitudinal depression, bounded below by a rather sharp border; a broader and more shallow depression, the lower boundary of which is well defined, marks the more advanced part of the ramus. These depressions indicate the insertions of muscles.

Both the upper (fig. 9) and lower (fig. 8) borders are obtusely rounded, the latter being the thickest. Along the inner side of the fragment a longitudinal channel (fig. 6, *e*) extends near the lower border, the upper boundary of the channel being produced inwards, especially posteriorly (*b*); above this boundary there is a deep, longitudinal depression (*d*) partly filled with matrix, and probably communicating with the (pneumatic ?) cavity of this part of the jaw-bone.

* Quenstedt, 'Ueber *Pterodactylus suevicus,*' 4to, 1855, tab. i, figs. 2, 4, 5.

The longitudinal depression (fig. 6, *d*) is bounded below by the angular element, or part answering to that marked 2 in *Pterodactylus suevicus*, and above by the sur-angular (*c*). This element appears to have coalesced with the articular one; but between the bone (*a, c*) and that marked *b* a true harmonia or toothless suture remains. The line below the letter *e*, in fig. 6, appears to be an accidental crack. The fractured anterior end of the fragment (fig. 10) indicates the extreme thinness of the wall of the bone, which consists of compact osseous substance. A part of the concave, articular, surface is shown at *a*, fig. 7.

A similar longitudinal depression on the inner side of the back part of the ramus, with its lower boundary produced as a ridge, and formed by the angular element (2), is indicated in the figure of the lower jaw of the *Pterodactylus suevicus* in Professor Quenstedt's memoir; according to the proportions of which jaw, the present comparatively enormous fragment would answer to almost the hinder half of that part of the ramus which has not united with its fellow to form the long symphysis, and it may be estimated as including one fourth of the entire length of the lower jaw, which would give to the Pterodactyle, yielding the present mandibular fragment, a head exceeding sixteen inches in length. It is probable, however, that the head of *Pterodactylus simus* was relatively shorter and thicker than in the smaller species of Pterodactyle.

The Basi-occipital (Tab. I, figs. 11, 12, 13).

A skull of the size above indicated would require an occipital condyle at least as large as that on the basi-occipital element figured in the above-cited plate. This condyle projects backward on a well-marked base too broad to be called a peduncle; the convexity is only hemispheric, with the transverse diameter predominating; its shape and position indicate great freedom of movement of the head upon the spine. There is no mark of a sutural surface for the exoccipitals on the expanded part of the bone (*b*); they were probably confluent, as in birds, with the basi-occipital, and have been broken away; the fractured surface (fig. 12, *b*) shows the large cancelli of this part of the occipital bone. The upper surface (*a*) indicates a wider foramen magnum, or neural canal, than that of the combined atlas and axis (fig. 14, *n*), and such a structure accords with the free and extensive movements of the head upon the spine indicated by the form and prominence of the condyle and its occipital cup (*c*).

Atlas and Axis (Tab. I, figs. 14, 15, and 16).

The anchylosed atlas and axis (figs. 14, 15, and 16) correspond in size with the above-described basi-occipital; they were obtained at the same time from the

same pit of the Upper Green-sand deposit near Cambridge. The condyloid ball (fig. 12, *c*) neatly fits the cup *c* of fig. 14, and most probably belonged to the same individual. All the characters described and figured in my paper on the 'Vertebræ of Pterosauria,'* and in a preceding monograph,† are repeated in the present larger specimens of the first and second neck-vertebræ. In the more transverse extension of the posterior articular ball of the axis (fig. 16, *b*) the present specimen agrees with the smaller of the two previously figured specimens of this part of the vertebral column.‡

Cervical Vertebræ (Tab. II, figs. 1, 2, and 4).

The middle (fourth or fifth?) cervical vertebra of a Pterodactyle, corresponding in bulk with that indicated by the fossils above described and figured (Tab. I, figs. 1—16; Tab. II, fig. 3), agrees in the proportions of length and breadth more with the smaller vertebræ (Tab. II, figs. 14—17, vol. for 1857) than with the vertebræ (ib., figs. 7—11) described in my former monograph of that date. It shows the same posterior extension of the centrum (fig. 2, *b*, *p*) beyond the neural arch (*n*), but with somewhat greater divarication of the hinder processes (*p*) than in figs. 18 or 11 of Tab. II of the above-cited monograph. The present specimen very strikingly illustrates the characteristic breadth and depression of the centrum of the middle cervicals of the large Green-sand Pterodactyles. The neural canal (fig. 2, *n*) appears to be proportionally more contracted than in the smaller cervical vertebræ; it is relatively much smaller than in any bird, marking well the reptilian nature of the extinct flying air-breather. The anterior surface of the diapophysial productions of the forepart of the base of the neural arch is marked by a groove extending from above and within outwards and downwards. The whole base of the arch has coalesced with the centrum; the major part, with the neural spine and zygapophyses, has been broken away.

An oblique side view of the last cervical vertebra of a similar-sized Pterodactyle is given in Tab. II, fig. 4, showing the more produced diapophysis (*d*), perforated by the vertebrarterial foramen (*f*), indicative of the development in this vertebral segment of a rudimental rib, and of its coalescence with the other elements, the whole extending below the level of the under part of the centrum. Above and behind this foramen is that for the admission of air into the bone; it is of a similar size, and of a narrow, elliptical form. The posterior zygapophysis (*z*) is now raised to a higher level than the anterior one, indicating the sudden bend of the neck at this part. The posterior processes (*p*) are smaller and less

* 'Philosophical Transactions,' 1859, p. 165, pl. 10, figs. 28—34.

† 'Palæontographical Society,' vol. for 1857, pp. 7, 8.

‡ Compare Tab. I, fig. 16, with Tab. II, fig. 14, and Tab. IV, fig. 2, of the 'Monograph' of 1857.

produced; the body of the vertebra is narrower, but deeper, than in the more advanced vertebra (fig. 1). The posterior zygapophysis is surmounted by a tubercle.

Caudal Vertebræ (Tab. II, figs. 13—16).

The caudal vertebra, from the anterior half of the tail (figs. 13 and 14), presents a size corresponding with the proportions of the Pterodactyle given by the above-described neck-vertebræ; the neural arch and zygapophyses continue to be distinctly developed at this region of the tail. There is a foramen (*o*), leading into the substance of the neural arch, on each side of the back part of that arch, and near the corresponding outlet of the neural canal. In the more distal vertebra (figs. 15 and 16) the neural arch has sunk, and seems almost blended indistinguishably with the centrum, which is much longer than in the vertebræ nearer the trunk. The zygapophyses cease to be developed; but the articular, shallow cup and ball at the ends of the vertebra show that the tail retained its mobility, and was not stiffened or anchylosed as at the corresponding part in *Ramphorhynchus*.

The Sternum (Tab. II, figs. 7—12).

According to the very able and instructive summary, by M. V. Meyer, of the osteology of the best-preserved examples of the skeletons of Pterodactyles, those, viz., from the lithographic slates of the Jurassic (Mid-oolitic) series of rocks, the sternum is a compound bone, consisting chiefly of a symmetrical, keelless, broad plate,* having an anterior process answering to the episternal process in the crocodile,† and with distinct side parts, having articulations for a few bony, sternal ribs.‡ As to its resemblance, otherwise, to the sternum of mammals, birds or reptiles, in regard to the articular surfaces for the scapular arch, nothing has been, hitherto, determined.

* "Das Brustbein ist ein schwach gewölbtes knöchernes Schild, das breiter als lang, und daher eher dem Brüstbein der nur kümmerlich mit *Flügeln* versehenen Strauss-artigen Thiere beider Erdhälften, als dem in den Flug-begabten Vogeln zu vergleichen ist. Es zeigt keinen Kiel oder Gräth, und Man könnte daher glauben, das die Stelle zum Ansatz eines kräftigen Flugmuskels fehlt, die Pterodactyln keine gute Flieger gewesen wären." ('Reptilien aus dem Lithographischen Schiefer,' fol., 1859, p. 17.)

† "Am Brustbein der Pterodactyln wird ein vorderer Forsatz wahrgenommen, der den Kiel ersetzt und den Brustmuskeln als Anheftungsstelle gedient haben wird. Dieser Theil erinnert an den Forsatz am Brustbein des Crocodils." (Ibid., p. 18.)

‡ "Bei *Ramphorhynchus Gemmingi* fand ich ausser den gewohnlichen Brustbein nach eine Platte mit Brustrippe welche die Verbindung mit den Kückenrippen unterhalten haben werden und wie in den Vogeln knöchern waren." (Ibid., p. 18, tab. x, fig. 1.)

The rich repository of remains of gigantic Pterosauria in the Upper Greensands of Cambridgeshire have added valuable evidence on these important points, and demonstrate a nearer approach to the keeled character of the breast-bone of flying birds than the specimens of the smaller species described in the under-cited works appear to demonstrate. By the kindness of Professor Sedgwick, I am enabled to compare the specimens of portions of the sternum acquired by the Woodwardian Museum with that which has recently been purchased by the British Museum. The best of these specimens consist of little more than the thicker and stronger, contracted forepart of the breast-bone (Tab. II, figs. 7, 8, and 9), broken away from the thin, expanded, fragile plate (*h*), of which it principally consists, and of which remains or impressions have been preserved in a few slabs of fine-grained stone of the Oolitic series, such as the lithographic slate; that of *Pterodactylus suevicus* * showing the posterior border of the symmetrical plate to be convex and entire, not notched or perforated, as in many birds. The forepart of the sternum of the gigantic Pterodactyle from the Cambridge Green-sand includes the major part of the anterior process, and also the pair of articular facets for the coracoids. The keel-like process in the specimen (Tab. II, figs. 7, 8, 9, *b, e, f*) is continued forward from that articular region (*d, c*), for an extent equal to the depth of the bone at the same part; but the process is not entire. Its base is gently convex at the sides, from the middle and thickest part of which it gradually narrows to a ridge, of about a line or less in thickness at both the upper and under margins; the extreme forepart being broken away, prevents the determination of the precise extent or contour of that end, but the convergence of the preserved parts of the upper and under margins indicate a convexly rounded termination (fig. 7, *e*). There is a gentle depression on each side of the beginning of the upper part of the ridge, which ridge is continued from a thickening or tubercle (figs. 7, 8, *b*), bounding anteriorly a small, deep, transversely oval depression (*d*) between the two articular surfaces for the coracoids (*c*). This tubercle answers to what I have termed the "manubrial process" in the sternum of birds,† and the above pre-coracoid part of the sternum answers to that process, confluent below, as in *Aptenodytes,* with the produced "keel." This, however, in *Pterodactylus*, quickly loses depth as it extends backwards along the mid-line of the under part of the sternum, some way behind the articular region, and has not quite subsided at the forepart of the expanded body of the breast-bone (fig. 9, *f*), from which the rest of the shield-like plate has been broken away. The sides of the post-coracoid part of the keel are gently concave; the lower border of the keel is first convex, then concave to near its posterior termination, both in a very feeble degree (fig. 7, *e, f*). Each of the

* Quenstedt, 'Ueber *Pterodactylus suevicus,* im Lithographischen Schiefer Würtembergs,' 4to, 1855.

† Art. "Aves," 'Cyclopædia of Anatomy and Physiology,' vol. i, 1836, p. 282, fig. 129.

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articular surfaces for the coracoid (figs. 7 and 8, *c*, *d*) is sub-triangular, convex transversely, concave in the opposite direction, with the lower angle continued down upon the side of the thickest part of this anterior portion of the sternum. The back part of the articular surface rises higher than the front, so that the general aspect of the surface is obliquely upward, forward, and outward. The two surfaces are separated by a non-articular depression (*d*), of the breadth of one coracoid surface; this depression is bounded, like the sella turcica of the human sphenoid, by a transverse rising or ridge of bone (fig. 7, *a*), continued between the hinder angles of the two articular surfaces, and in front by the manubrial tubercle (*b*), from which the upper border of the produced keel is continued. The sternum contracts behind the articular region at *g*, figs. 8 and 9, and then expands rapidly in the horizontal direction, to form the broad, lamelliform body of the bone (*h*), which, in *Pterodactylus suevicus*,* appears to have been almost semicircular in shape, and to have extended backward beneath about one half of the thoracic abdominal cavity. The upper surface of the forepart of the sternal plate is concave, and it becomes flatter as it expands. The lateral and lower surfaces are also concave vertically, with linear markings, showing the implantation of the pectoral muscles that filled those concavities on each side the keel. Sufficient thickness of the bone remains at the fractured posterior part (*f*), where the keel has not subsided, to show the widely cancellous, and seemingly pneumatic, texture of the bone.

The similar, but smaller and more mutilated, portion of a sternum of a Pterodactyle (Tab. II, figs. 10—12) shows the same form and position of the coracoid articular surfaces, the non-articular intermediate depression, the lateral emarginations or contraction of the sternum behind the part supporting the coracoids, and the backward extension of the keel beneath a certain proportion of the expanded body of the sternum, forming the hollows for the lodgement of the pectoral muscles.

A sternum of the shape and proportions above described plainly indicates pectoral muscles of great bulk and strength, by the extent of origin it afforded to them, and by the depth of the depressions they filled on each side of the keel; but to what purpose the limbs moved by those muscles were put is best inferred from the characters of the bone into which they were inserted. If, however, the peculiar development of the fore limbs of the Pterodactyle had not been known, the evidence of a pneumatic or widely cancellous structure in the thicker forepart of the breast-bone would have suggested a power of locomotion in its original possessor akin to that of the class to the sternum of which that of the Pterodactyle makes, upon the whole, the nearest approach.

It is true that the sternum is broad and shield-shaped in the Apteryx and other land-birds devoid of the power of flight; but this form, together with the

* Quenstedt, op. cit.

strong coracoids and their articulation with the sternum, relates, in them, to the mechanism of respiration. The ossified sternal ribs, with their articulations to the sides of a broad sternum, indicate a like function of the breast-bone in the Pterodactyle, viz., to expand the thoracic abdominal cavity, when such plate of bone, with attached but jointed sternal ribs, was pressed down by the coracoids.* The superadded keel, co-extended anteriorly with the connate manubrial process of the sternum of the Pterodactyle, plainly bepeaks, however, additional functions; but these might have been, as M. Von Meyer suggests, the same as in the penguin, or even in the mole. And, at this point, the physiologist in quest of the locomotive relations of the sternum, would pass to the comparison of the humerus and other bones of the fore limb; or, failing those, to a more minute scrutiny of the texture of the breast-bone of the Pterodactyle. It is almost superfluous to remark that the evidence of the fore limbs had shown the Pterodactyle to have been a flying animal long before anything was precisely known as to its sternum.

The development of the interpectoral process or keel of the sternum in the Pterodactyle exceeds that in any of the bat tribe; and it may be confidently concluded that the flight of the winged reptile might have been, at least, as swift and of as long continuance as in the *Pteropi*. But, viewing the pneumaticity of the bones of the Pterodactyle, and the relatively greater and more continuous development of the interpectoral crest of its sternum, I am led to believe it to have been a creature of more extensive, continuous, and powerful flight than is now enjoyed by any bat; and the Pterodactyles may at least have been as capable of migration as the great frugivorous *Chiroptera*. The structural affinities, however, of the Pterodactyles to the cold-blooded air-breathers, and their analogy, in wing-structure, to the bats, indicate that they might have possessed the faculty of becoming torpid, and of so existing during a period when their food in a given locality was not attainable.†

* From the appearances presented by the crushed specimen of *Pterodactylus Gemmingi*, imbedded in a slab of lithographic slate, I believe that the part of the sternum showing those articulations has been accidentally separated from the rest of the fractured bone. (See Von Meyer, Tab. x, op. cit.) The estimable author concludes that the marginal portion of sternum, with articulations with ossified sternal ribs, was originally distinct from the body or main plate of the sternum: but the plate of the specimen he describes shows fractures and some mutilation of the bones.

† The inferences from what was previously known as to the structure of the sternum of the Pterodactyle are thus expressed by M. H. v. Meyer, in his summary of the knowledge of the Pterosauria, in 1859: "Es zeigt keinen Kiel oder Gräthe, und man könnte daher glauben, dass, da die Stelle zum Ansatz eines kräftigen Flugmuskels fehlt, die Pterodactyln keine guten Flieger gewesen wären. In dem Mangel eines Kieles scheint indess nur eine Andeutung zu liegen, dass die Thiere keine Vögel waren. Eben so wenig werden sie Wanderthiere gewesen seyn, und bedurften daher auch keines so starken Brustmuskels. Das Brustbein der Fledermäuse gleicht sogar durch die Gegenwart eines Kiels mehr dem in den Vögeln

In no other reptile does the sternum present coracoid articulations so shaped and so placed as in the Pterodactyle. The Crocodilia, in which, as in Pterosauria, the clavicles are wanting, show the broad, sternal margins of the coracoids ligamentarily attached to the middle of the lateral border of the sternum.

In bats the obtuse, sternal ends of the clavicles are applied to protuberances of the manubrium above the articulations of the first pair of ribs. Only in birds are distinct synovial articular cavities provided for the coracoids, which, in the main, are situated and shaped as in the Pterodactyle. The differences are these: the concavity and the convexity being (as, *e. g*, in *Aptenodytes*), the same, the bent grooves so formed are much longer than in the Pterodactyle, with a concomitant greater expansion of the ends of the bones they firmly lodge. The coracoid grooves are divided by a non-articular, median depression in *Aptenodytes*, but this, in some other birds, is wanting, the coracoid grooves decussating across the middle line, *e. g.*, in the Heron.* There are various minor modifications of the coracoid grooves in the breast-bone of birds.

The marked distinction in the breast-bone of the Pterodactyle is its compression behind the coracoid articulations, and the distinct commencement of the shield-like expansion behind that articular part.

In most birds the "manubrium" projects from the mid-space between the coracoid grooves, and is distinct from the "keel;" in some it is bifurcate; in the penguins it is as little developed as in the Pterodactyle, and is as directly continuous or connate with the forward production of the keel. In this production *Aptenodytes patachonica* most resembles, amongst birds, the Pterodactyle. The parts are homologous, and if we name that production the forepart of the keel of the breast-bone in the aquatic bird, we must apply the same name to it in the Pterodactyle; only in the latter the keel subsides sooner beneath the expanded part of the sternum.

In the Crocodilia the broad, thin, sternal borders of the coracoids are attached by fibrous substance to the fibro-cartilaginous, or, in old animals, partially

Es besitzen aber auch die Maulwürfe am brustbein diesen Kiel, der daher nicht unbedingt als ein Zeichen des Flugvermögens gelten kann; er setzt eigentlich nur starke Brustmuskeln voraus, die daran befestigt waren. Selbst in den Schwimmvögeln die nicht zu fliegen vermögen ist der Kiel vorhanden für starke Brustmuskeln, die hier zum Schwimmen eben so nöthig sind wie dem Maulwürf zum Graben. . . . . Aus diesen Betrachtungen ergiebt sich, dass der Pterodactylus nach der Beschaffenheit seines Brustbeins weder ein eigentliches Wasserthier, noch ein Gräber war, vielmehr ein Thier der Luft." ('Reptilien aus dem Lithographischen Schiefer,' &c., fol., p. 17.)

Professor Quenstedt, however, seems to me to have rightly appreciated the homology of the forepart of the sternum and the physiological deductions from it: "Der Kamm springt vorn einen halben Zoll weit über die Fläche des Knochens hinaus, gibt daher Beweis genug, das das Thier fliegen konnte." (Op. cit., p. 44.)

* 'History of British Fossil Mammals and Birds,' 8vo, 1846, p. 556, fig. 236.

ossified, plate, representing the sternum of struthious birds. The bony sternum, or "episternum," is long, narrow, and depressed; it is considerably produced in advance of the coracoids, but this produced part is flattened horizontally. If it be compared with the pre-coracoid part of the sternum in the Pterodactyle or penguin, it is not more like the one than the other. In the main, the Pterosaurian breast-bone, like the scapular-arch, is formed on the ornithic type, but the post-coracoid, lateral emarginations are distinctive Pterosaurian characters.

The Humerus of Pterodactylus (Tab. III).

The fragile texture of the bones of the Pterodactyle, and the consequently crushed or broken state in which those of the wings more especially have hitherto been usually found, have precluded any precise description or figures of the articular surfaces, or of the configuration of the extremities of these bones. And yet such particulars are absolutely requisite for defining the resemblance of the Pterosaurian humerus to that of the bird and reptile, and for acquiring this element in the determination of the degree of affinity or relation of the Pterosauria to those classes respectively.

The remains of the very large species of Pterodactyle from the Cretaceous formations of Kent and Cambridgeshire have furnished materials for advancing this desirable knowledge in regard to the structure of the vertebræ,* and I have now similar means of contributing more precise information respecting the structure of the proximal end of the humerus than has hitherto been possessed. For the subjects of this study and comparison I am chiefly indebted to Professor Sedgwick. But, in proceeding to impart the results, I must premise some notice of the character of the humerus in birds, in which I shall avail myself of the terms indicative of aspect and position proposed by Dr. Barclay, in his 'Anatomical Nomenclature.'

Proximal signifies the upper, *distal* the lower, ends of the bone, as it hangs in man; *anconal* is the posterior, *palmar* the anterior, surface, as when the palm of the hand is directed forward; *radial* is the outer, *ulnar* is the inner, side, according to the same position of the human arm and hand. *Proximad, palmad,* &c., are adverbial inflections, meaning towards the proximal (upper) end, and towards the palmar (anterior) side.

In the bird, then, the humerus has a smooth shaft, sub-elliptic in transverse section, with expanded ends, the proximal one being the broadest. Lengthwise the bone is gently sigmoid, the proximal half being convex palmad, the distal half

* Phil. Trans., tom. cit.

concave, with the plane of the terminal expansions vertical, as the bone extends along the side of the trunk from its scapulo-coracoid articulation backward, in its position of rest.

The head of the humerus is an elongate, semi-oval convexity (Tab. III, fig. 8 *a*), with the long axis transverse from the radial to the ulnar sides (vertical, as naturally articulated), and with the ends continued into the upper (*b*) and lower (*c*) crests. Of these, the upper one (*b*, figs. 6—8), in the natural position of the bone, is on the same side as the radius, the lower, more tuberous one (*c*), is on the same side as the ulna; the one marks the "radial" side, the other the "ulnar" side, of the bone. The side of the humerus next the trunk answers to that called "anconal" (fig. 7), the opposite side to that called "palmar" (fig. 6).

The expanded, proximal part of the shaft on the palmar side (fig. 6) is concave across, convex lengthwise; on the anconal side (fig. 7) it is convex across to where the ulnar ridge (*c*) bends anconad near the pneumatic orifice (*p*).

The radial crest (*b*) answers to the "greater tuberosity" and to the "pectoral" and "deltoidal ridges" in mammals; the "ulnar" crest (*c*) to the "lesser tuberosity," and the ridge for the "latissimus dorsi," in mammals.

In a few exceptions the shaft of the humerus is almost cylindrical, in still fewer (*e. g.*, ***Aptenodytes***) it is flat.

In the vulture (*V. monachus*), the ulnar crest forms a thick tuberosity at its proximal end (fig. 7, *c*), projecting anconad, and overarching the "pneumatic" foramen (*p*); it descends a short way obliquely palmad, decreasing in breadth, but still thick, convex, and terminating obtusely (fig. 6, *c'*). The radial crest (fig. 6, *b*) better merits the name; it extends twice the length of the ulnar one, down the shaft, to the palmar side, towards which the whole crest is slightly bent; its margin describes a very open or low, obtuse, angle at its middle part. A ridge (*r*) upon the palmar side of its distal half indicates the boundary of the insertion of the pectoralis major into the crest. At the middle of the anconal surface of the proximal part of the shaft there is a low, longitudinal ridge (*l*).

At the distal part of the humerus a ridge on the radial side of the palmar surface, and a rising of the bone on the ulnar side of the same surface, diverge to the opposite angles or tuberosities of the expanded end of the bone; they include a shallow, sub-triangular concavity above the articular surfaces. These are two, and are convex.

The radial surface is a narrow, sub-elongate convexity, extending from near the middle of the palmar surface obliquely to the lower part of the radial tuberosity, where the convexity subsides; it is very prominent at its palmar end, with a groove on each side, the deeper one dividing it from the ulnar, articular convexity. This is of a transversely oval or elliptical shape, most prominent

palmad; all the part of the end of the humerus forming the two articular convexities is as if bent toward the palmar aspect. The ulnar end of the ulnar convexity is bent, and continued anconad to that end of the ulnar tuberosity. An oblique, longitudinal channel divides the anconal end of the radial tuberosity from an almost longitudinal ridge, which is nearer the middle of the anconal side of the distal end of the humerus; a similar, but shorter, longitudinal ridge or rising of bone, terminates in the anconal part of the ulnar tuberosity. Between the above almost parallel ridges the anconal surface is nearly flat transversely; it is traversed along the middle by a low, narrow, longitudinal ridge. Lengthwise the bone is here convex.

The differences in the humerus of different birds are seen chiefly in the forms and proportions of the proximal crests; the radial one in the *Columbidæ*, *e. g.*, is shorter and more produced than in most birds of flight. The humerus in the swift and humming-bird is distinguished by special modifications.

In the crocodile (Tab. III, figs. 9—12), the articular head of the humerus (fig. 12, *a*) is a transversely elongated, sub-oval convexity; it is continued upon the short, obtuse, angular prominence (*c*), answering to the ulnar crest or tuberosity in the bird. The radial crest (fig. 9, *b*) begins to project from the shaft at some distance from the head of the bone; it is shorter, thicker, more prominent, and projects more directly palmad than in the bird. The humerus presents a similar sigmoid flexure lengthwise to that in the bird, but the ulnar contour of the shaft, as it descends from the ulnar end of the head of the bone, describes a concave line to the ulnar condyle; the radial contour is sigmoid, and not affected by the radial crest, as in the bird. There is a longitudinal ridge (fig. 10, *d*) on the anconal surface close to the radial border.

The humerus of the Pterodactyle (ib., figs. 1—5) is shorter in proportion to the expanse of its proximal end than in either the bird or crocodile, and it appears to have a straighter shaft. It conforms at its proximal end more with the Crocodilian than the Avian type. The ulnar crest, or tuberosity (*c*), is rather more prominent and better defined than in the crocodile, but the radial crest (*b*) is much more developed than in either the crocodile or bird. It resembles that of the crocodile in being more directly bent palmad, or what would be outward in relation to the side of the trunk, in the natural position of the bone at rest.

The crest begins, above, at the radial and palmar end or angle of the articular head of the bone, and rapidly expands, bending palmad, with a base co-extensive with one fifth of the length of the humerus, inclining, as it descends (fig. 3), to the palmar side, and ending below by a rough tuberosity projecting at a right angle from the shaft of the bone; the lower sharp margin (fig. 1, *b'*) of the tuberosity passes by a quick curve, and subsides upon the cylindrical shaft. The palmar surface of the proximal part of the humerus, by the production in that direction of the ulnar

tuberosity, but more especially by the direction of the large, radial crest (*b*), is more concave across than in birds. Between *b* and *c'*, *e*, *g*, in fig. 1, it is gently convex lengthwise, and is very smooth.

A longitudinal ridge (fig. 1, *r*), along the distal half and palmar side of the base of the radial crest, indicates, as in birds, the insertion of the strong and large pectoral muscle.

The articular head of the bone is reniform, not uniformly convex, as in birds, but slightly concave between the beginnings of the radial and ulnar crests or processes on that moiety of the head next the palmar side (fig. 3, *a*). At the opposite (anconal) side (fig. 2, *a*), the head projects slightly beyond or overhangs the shaft, the upper part of which, on the anconal side, is slightly concave lengthwise, very convex across, more so than in birds, and without trace of the median longitudinal ridge (*l*, fig. 7). It is equally devoid of the ridge which, in the crocodile (fig. 18, *d*), runs close to the radial side of the anconal surface.

The shaft is more cylindrical than in birds. The pneumatic foramen (figs. 3, 5, *p*) is situated a little below the radial end of the head of the bone, on the palmar side of the bone; in the vulture, and most birds of flight, it is situated on the opposite side (fig. 7, *p*). The pneumatic texture of the shaft is as well marked as in any bird of flight.

In looking directly upon the palmar side of the humerus in the bird one has an oblique, foreshortened view of the radial crest, the base of which lies wholly along the radial margin. Taking the same view of the humerus of the Pterodactyle as in Tab. III, fig. 3, we look almost directly upon the edge of the radial crest (*b*, *b'*), the base of which has inclined below from the radial upon the palmar surface. A corresponding view of the humerus of the crocodile (fig. 11) shows the whole base of the radial crest on the palmar surface, clear of the radial border, and the opposite side of the crest to that in the bird is obliquely brought into view. (In the figure 11 the radial side of the shaft is rather too much turned towards the eye.)

In the position and shape of the radial crest the Pterodactyle is between the bird and the crocodile; in the transverse extent of the crest it exceeds both. The crest differs in extent and shape in different species of the Pterodactyle. In fig. 1 the ulnar side of the shaft is turned so far towards the eye as to permit the whole breadth of the radial crest (*b*) to be seen. The degree to which the radial crest projected in the humerus of the large Cretaceous Pterodactyle (Tab. III, fig. 1) is only shown at its lower part, the upper, thinner portion being broken away. Relatively to the size of the head of the bone, the extent of the base is greater than in the smaller species of Pterodactyle, a corresponding portion of the humerus of which is represented in fig. 5, from the same aspect as fig. 1. The

extent of the base of the radial crest in fig. 5 corresponds with that of *Pterodactylus suevicus.**

In *Ramphorhynchus Gemmingi* the radial crest, with a similar short origin, has a remarkable transverse extent, and expands at its termination, so that both upper and lower margins are very concave.† The latter is of much greater relative extent than in the large Cretaceous Pterodactyle (Tab. III, fig. 1). The Wealden Pterodactyle (*Pter. ornis*) resembled *Ramphorhynchus* in the proportions of the radial or outer process (*g*, fig. 5, 'Quart. Journal of the Geol. Soc.,' 1845, p. 99).

The determination of the homologies of the processes from the proximal end of the humerus of the Pterodactyle with those in the bird and crocodile enables one to recognise the specimen (figs. 1—3 and fig. 5) as part of the right humerus.

Fig. 4 is part of the left humerus, from the Upper Green-sand of Cambridgeshire, but was drawn upon the stone without reversing, to facilitate its comparison with fig. 1, from the Middle or White Chalk of Kent, which it resembles in the extent of origin of the radial ridge (*b*).

Carpal Bones (Tab. II, fig. 6; Tab. IV, figs. 5—9).

The two bones (Tab. IV, figs. 5, 6, and figs. 7—10) correspond in size so much more with that of the distal extremities of the radius and ulna than with that of the same part of the tibia, as to leave a conviction that they are carpal bones, and they afford instructive evidence of the characters of those bones in the Pterodactyle. Specimens of more or less entire, but dislocated, skeletons of the smaller kinds of Pterodactyle from Oolitic strata, especially that of *Pterodactylus suevicus* from the lithographic slates of Wirtemburg,‡ and that of *Ramphorhynchus Gemmingi* from the same formation at Eichstadt,§ have demonstrated the presence of at least two large carpal bones, with one or two smaller ones, the two carpals forming a first and second row; but the figures are too small and indefinite to permit the matching with them of either of the larger and probably better-preserved carpal bones from the Cambridge Green-sand.

The first to be described is subdepressed, subtriangular in shape, with a general tendency to convexity on one articular surface (Tab. IV, fig. 8), and to concavity

* Quenstedt, op. cit., tab. i, *cr*, *cl*.

† H. v. Meyer, op. cit., tab. ix. A. Wagner, 'Fauna des Lithogr. Schiefers,' 4to, 1858, taf. xvi.

‡ Well described and figured by Professor Quenstedt, in his treatise 'Ueber *Pterodactylus suevicus*,' 4to, Tubingen, 1855.

§ H. v. Meyer, op. cit., tab. ix, fig. 1.

on the opposite surface (fig. 7); but both these surfaces are irregularly undulated, as shown in the figures; the more concave surface being also impressed by a deep hemispheric pit. I conjecture that this bone formed the proximal part of the carpus, and that the pit may have received a process of the distal end of one of the antibrachial bones. The opposite, probably distal, and more convex surface (fig. 8) is divided into two slight convexities, by a shallow, wide channel, crossing the bone obliquely. The convexity (*a*) meets the concave surface on the other side of the bone (*e*, *f*) by their convergence to the basal border or margin, which presents a slight notch. The opposite end of the bone forms the obtuse apex (*d*), which is a little bent down towards the concave side. On this side (fig. 7) the notch is continued into an angular channel, which divides the two shallow, concave surfaces (*e* and *f*) occupying the basal half of this surface; a little nearer the apex than the middle of the bone comes the hemispheric pit, with a small depression on one side of it.

Fig. 9 shows the thickest or deepest, non-articular side of the bone, sloping to the end of the facet (*f*), and with the apical tuberosity (*d*) at the opposite end.

Fig. 10 is taken looking upon the convex surface from the notched base (*a*).

Fig. 8 may correspond with the surface of the carpal bone in *Pterodactylus suevicus,* marked 1, in the bones of the left wing in Professor Quenstedt's Plate; and the side view of the same bone in the carpus of the right wing gives an indication of the produced apex. The outline of the large proximal carpal in *Pterodactylus* (*Ramphorhynchus*) *Gemmingi,* in M. v. Meyer's Plate, accords in a general way with the profile of the narrower side of the present bone, which, for the convenience of indication and description, might be called the "scapho-cuneiform." I have no proof, however, from knowledge of its precise connexions, of the accuracy of this determination; but strongly suspect that the bone may represent more than one of the proximal carpals in the mammalian wrist, and probably the two proximal bones in the carpus of the crocodile.

In Tab. II, fig. 6, a scapho-cuneiform bone is figured, which, from its size, might belong to *Pterodactylus simus;* it differs from that in Tab. IV, fig. 7, not merely in size, but, apparently, in a greater relative breadth of the surfaces (*e* and *f*); their margins forming the base of the triangle have been, however, abraded.

The second large wrist-bone (Tab. IV, figs. 5 and 6), if the foregoing be rightly compared, will match with the carpal bone articulating with the proximal end of the metacarpal of the fifth or wing-finger in the plates of *Pterodactylus suevicus,* and of *Ramphorhynchus Gemmingi,* above cited; and it will consequently answer to or include the "unciforme," by which name it will be here described and figured.

Both proximal and distal surfaces show well-defined, concave articulations. On the more concave surface (fig. 5) there is an oblong, articular depression (*g*), continuous at the margin (*h*) with a surface on the opposite side of the bone; a more irregular undulated channel, deepest at the middle part (*i*), occupies the rest of the surface, but the end of the bone opposite (*h*) has been broken away. Fig. 6 shows two shallow, articular channels (*k* and *l*), partly divided near the end (*h*) by a tract of non-articular surface.

In birds the base of the metacarpal of the digitus medius has the "os magnum" connate therewith, it also becomes confluent with the bases of the second and fourth metacarpals. Between this compound bone and the antibrachium two distinct carpal bones partially intervene, being wedged between the metacarpus and antibrachium, one on each side. The Pterodactyle, in the complete separation of the metacarpus from the antibrachium, by two successive carpals, answering to the two rows, adheres more closely to the Reptilian type; but differs in the much greater expanse and complexity of the carpals, and in their minor length.

Ungual Phalanx (Tab. IV, figs. 11 and 12).

The ungual phalanx (Tab. IV, figs. 11 and 12), accords in size with that of the limb indicated by the carpal bones (figs. 5—10). The articular surface presents two trochlear concavities, extended vertically, narrow transversely, divided by a median ridge; the upper angle is rather produced; below the trochlea is a small depression, and below this the bone projects in the form of the rough protuberance for the flexor tendon. On each side of the phalanx is the curved vascular groove, beneath which, in some specimens, the bone slightly expands. In one specimen a second, more shallow groove is shown on one side, nearer the upper margin of the bone.

ORDER—*SAUROPTERYGIA*, *Owen*.*

Genus—POLYPTYCHODON, *Owen*.

POLYPTYCHODON INTERRUPTUS, *Owen*.

In the 'Monograph of the Fossil Reptilia of the Chalk Formations,' p. 200,† certain dental and osteological characters of a large extinct Saurian were described and figured, confirmatory of the distinct generic form of reptile, for which had been proposed the name *Polyptychodon*,‡ having reference to the numerous longitudinal ridges and grooves, giving a minutely folded surface to the enamel covering the crown of the tooth. In my 'Report on British Fossil Reptiles,' the genus was referred to the 'Sauria incertæ sedis,' no other parts save the teeth being then (1841) known. A few years later a portion of jaw was discovered in the Lower Chalk of Kent, showing that the teeth were implanted in distinct sockets, as in the *Crocodilia*. This specimen I described and figured in the work of my friend, Mr. Dixon, entitled 'The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex.'§

Some large fossil bones from a Green-sand quarry near Hythe, Kent, described in the above-cited 'Monograph on the Fossil Reptilia of the Cretaceous Formation,'‖ as probably belonging to *Polyptychodon*, showed that "the pubis and ischium approached somewhat to the Plesiosaurian type."¶

Cranium and Teeth (Tab. IV, figs. 1—3).

I have lately been favoured by Mr. George Cubitt with the inspection of part of the cranium, including portions of jaws with teeth, of *Polyptychodon interruptus*, discovered in cutting a railway tunnel through the Chalk formations near Frome, Somersetshire, which gives further evidence of the Plesiosauroid

* Report of the British Association, 1859, p. 153.

† Volume of the Palæontographical Society, 4to, for 1851.

‡ This genus was established, on the characters of detached teeth from the Chalk, in the author's "Report on British Fossil Reptiles," 'Trans. of the British Association,' 1841, p. 156.

§ 4to, 1848, tab. xxxviii, fig. 3.

‖ Monograph, cit. pp. 201—209.

¶ Ibid., p. 206.

affinities of the genus, in the presence of a large oblique "foramen parietale" between the frontal and parietal bones (Tab. IV, fig. 1, *p*).

The parietal bone (7) is much compressed, and developes a sharp and rather lofty median crest behind the foramen (*p*), which crest divides the temporal fossæ (*t*, *t*). Behind this crest the parietal bone expands transversely, and assumes a tri-radiate form, the two transverse rays uniting with the mastoids (8, 8). These are very powerful bones, bounding the outer and back part of the temporal fossæ; they are smooth and slightly convex above, rough and slightly concave at the back part near the angle, where a surface is thus formed for the attachment of some powerful muscle. The part of the mastoid which curves forward from the angle to form the back part of the zygomatic arch, becomes compressed, and terminates above in a ridge (*r*). The substance of the mastoid is extensively excavated, apparently for the upper part of the acoustic chamber.

The frontal bone (11) is overlapped behind by the parietal, and appears to have been divided by a median "harmonia," or smooth suture; the receding halves of the frontal behind, as they pass beneath the parietal, form the forepart of the foramen parietale. The back part of the foramen is formed by a notch in the forepart of the single and undivided parietal. The canal from the foramen extends obliquely downward and backward. The long diameter of the foramen is 1 inch; the breadth of the back part of the cranium is 16 inches; the breadth of the back part of each temporal fossa is 6½ inches. The power of the muscles acting upon the lower jaw must have been very great.

A portion of a symmetrical bone, 10 inches long, which formed the upper median part of the face, anterior to the orbits, represents part of an undivided nasal bone (15) and shows that bone to have been long, narrow, straight longitudinally, convex transversely above, as if the upper part of the face had been traversed by a low, obtuse, median rising.

In most of these characters may be discerned a closer affinity to the Plesiosauroid than to the Crocodilian type.

The expanse of the temporal fossæ equals that in the *Plesiosauri* and *Teleosauri*, but no species of the latter genus of *Crocodilia* has presented the "foramen parietale," whilst it is a constant character in the *Plesiosauri*, *Ichthyosauri*, and *Labyrinthodontia;* many of the modern lizards also present the same foramen. The portion of the upper maxillary bone, figured of the natural size at fig. 2, Tab. I, shows the same obliquity of the separate sockets of the teeth as exists in those at the forepart of the bone in certain *Plesiosauri*, and the small separate foramina (*o*, *o*), at the inner and back part of the large alveoli, which had been perforated by the summits of the successional teeth, are of plesiosauroid character. I have seen portions of jaws of *Plesiosaurus megacephalus* in which the appearance of a double row of teeth was caused by

the length of the protruding summits of the new teeth before they displace the old, when they are pushed, causing absorption of the intervening osseous bar, into the large sockets of the teeth they replace.

The crown of the teeth of *Plesiosaurus* is, moreover, one which that of the teeth of *Polyptychodon* (fig. 3) resembles in the ridged enamelled surface and sub-circular transverse section; but the teeth of true *Plesiosauri* are proportionally longer and more slender, whilst those of *Polyptychodon* in the proportions of the crown more resemble the teeth of the crocodilian genera *Goniopholis* and *Madrimosaurus.*

The microscopic structure agrees equally with the plesiosauroid and crocodilian modifications of the dental tissues. In Tab. I, fig. 3, *b* shows the shape of the base of the deeply implanted tooth, at the part where it had been broken in one of the specimens (*a*), accompanying the portion of cranium from the Lower Chalk at Frome. Fig. 3 is a more entire tooth of the same individual.

Cervical Vertebra (Tab. V, figs. 1 and 2).

I next proceed to offer other evidences tending to show the affinity of *Polyptychodon* to *Plesiosaurus.* In the Upper Green-sand deposits near Cambridge, and in the Neocomian formations of similar age at Kursk, south of Moscow, large vertebræ of the Plesiosauroid type have been discovered, together with teeth of *Polyptychodon,* which vertebræ I believe to belong to that genus.

The centrum of a cervical vertebra, from the Cambridgeshire Upper Greensand (figured in Tab. V, figs. 1 and 2), measures 4 inches 3 lines in length, 5 inches 3 lines across the terminal articular surface, and 7 inches in total breadth, including the transverse processes (*pl, pl*). Each of these projects about an inch from the side, rather nearer the fore than the back part, of the vertebra, and terminates in a flattened surface for the ligamentous articulation of the cervical rib, which surface measures 2 inches 3 lines by 2 inches in its diameters (fig. 1, *pl*). The articular surfaces of the centrum are nearly flat.

This vertebra, with which no other teeth save those of *Polyptychodon,* from the same formation and locality, agree in size, thus presents the essential characters of the neck-vertebræ of *Nothosaurus* and *Plesiosaurus,* and must be referred to the order *Sauropterygia.** The specimen is preserved in the Woodwardian Museum at Cambridge. It was obtained from the Green-sand

* See the "Classification of Reptilia," 'Reports of the British Association,' 1859, p. 159, and 'Palæontology,' 8vo, 1860, p. 209.

phosphatic-nodule works at Haslingfield, about four miles from the town of Cambridge.

In a collection of Upper Green-sand fossils from the vicinity of that town, lately purchased by the British Museum, there is the centrum of a dorsal vertebra of corresponding dimensions. It presents the usual characters of the Plesiosauroids; the articular ends are very slightly concave, with a moderate prominence in the middle, of a subcircular form, about the size of a crown-piece. The sides are gently concave lengthwise; the under surface is so in a less degree; this non-articular surface is smooth at the middle part, with longitudinal, irregularly wavy ridges and grooves for an inch at the margin, which are well defined; this roughness indicates the attachment of the fibres of the capsular ligament. The fore-and-aft diameter of the centrum is less at the summit than at the base; here it measures 4 inches 6 lines; along the neural canal it is 4 inches; the smooth tract caused by the impress of this canal is 6 lines across the narrowest part, and 2 inches across the widest end. The neurapophysial pits are shallow, with a rugged surface 3 inches 6 lines long by 1 inch 9 lines in diameter; the small part of the upper surface of the centrum not covered by the neurapophysis is at the end where the neural canal is widest, and which is most probably the hinder end; there are two venous foramina on one side and three on the other side of the middle of the lower surface of the centrum. The breadth of the articular surface is 6 inches 3 lines; its depth, or vertical extent, the same.

The same conformity, in regard to their proportional size, characterises the teeth of *Polyptychodon* and the associated large Plesiosauroid vertebræ from Kursk. I am indebted to the able engineer and zealous palæontologist, Colonel Kiprianoff, for the opportunity of examining the specimens discovered by him in that locality.

The centrum of one of these vertebræ belonging to the dorsal region, from the Neocomian formations at Kursk, measures 4 inches in length and 5 inches 4 lines in breadth; the terminal articular surfaces are flat; between them the lower surface of the centrum is straight, but at the sides it is gently concave; there are two venous foramina, 2 lines apart, at the middle of the under surface of the centrum.

Portions of ribs from the Upper Green-sand of Cambridgeshire agree in texture, and correspond in proportional size, with the cervical and dorsal vertebral bodies with which they were associated. I have selected one of these fragments for representation in Tab. V, fig. 3, because it shows a well-marked ridge (*s*) on one side, a character I have not seen in the ribs of true *Plesiosauri;* and these portions of ribs, of probably *Polyptychodon,* present a less rounded transverse section.

Atlas and Axis (Tab. VI).

The centrums of the first and second cervical vertebræ coalesced, as in *Plesiosaurus,* from the same locality and formation as the hinder cervical vertebra, Tab. V, present the proportions, in regard to their antero-posterior diameter, of the cervical vertebræ of *Pliosaurus;* but they belong, in all probability, to the same Plesiosauroid reptile as the vertebræ previously described, and I refer them to the genus *Polyptychodon.*

Like most of the fossils from the Haslingfield locality, they have been subject to attrition. The contour of the centrum of the atlas (fig. 1) has been subcircular; its anterior articular surface (*c, a,*) is concave, and has afforded a large proportion of the bottom or middle part of the cup for the occipital condyle. The lower part of the cup has been completed, as in *Plesiosaurus,* by a wedge-shaped hypapophysis, the articular surface for which is shown at *h, y*; the upper contour has been contributed by the neurapophyses, the articular surfaces for which may be discerned at *n, p,* on each side of the smooth neural tract *n,* in figs. 2 and 3.

The line of the original separation of the bodies of the atlas and axis may be traced; the second hypapophysis, or part of it, remains anchylosed to their inferior interspace; it has been much smaller than the first. The posterior surface of the centrum of the axis vertebra (fig. 2, *c, x*) is almost flat, showing the Plesiosauroid nature of the bones. In the similarly short vertebræ of an Ichthyosaurus, this surface would have been deeply concave.

Having thus a proof of the plesiosauroid nature of these anchylosed vertebræ, the same grounds for referring them to *Polyptychodon* apply, as to the posterior cervical vertebra (Tab. V, figs. 1 and 2) of more ordinary plesiosaurian proportions. Between that vertebræ and the axis I infer, therefore, that the anterior cervicals rapidly diminished in length, and that the anterior ones exhibited the same Ichthyosaurian shortness as they do in *Pliosaurus.* The magnitude of the head, jaws, and teeth, of *Polyptychodon* resembled that of its more ancient congener from the Kimmeridge Clay, and the supporting part of the spinal column appears to have been shortened and strengthened accordingly.

It is probable that the large Plesiosauroid paddle, from the Chalk of Kent, the phalanges of which are figured in the 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' for 1851 (Palæont. Soc.), pl. 17, belonged to *Polyptychodon.* Thus the evidence at present obtained respecting the huge but hitherto problematical carnivorous Saurian of the Cretaceous period proves it to have been a marine one—the rival and contemporary of the equally huge Maestricht lizard. But whilst *Mosasaurus,* by its vertebral, palatal, and dental characters, oreshadows the saurian type to follow, *Polyptychodon* adheres more closely

to the prevailing type of the sea-lizards of the great geological epoch then drawing to its close.

The seas in which the English Chalk hills and cliffs were formed, and by which they were modified in the course of upheaval, must have teemed with life, and have been traversed by shoals of fishes needed for the sustentation of the numerous kinds of large marine reptiles now known to have existed during that period, and all of which were provided with jaws and teeth adapted, under diverse secondary modifications, to the capture and destruction of the finny races. Of these carnivorous reptiles some, as, *e. g.*, *Ichthyosaurus campylodon* and *Plesiosaurus Bernardi*, were large species of genera represented throughout the oolitic period; others, as, *e. g.*, *Leiodon* and *Mosasaurus*, offer generic or family modifications of the Saurian structure, unknown in any other than the Cretaceous deposits. The subject of the present section, as gigantic as the Maestricht *Mosasaur*, manifests an extreme modification of the Plesiosauroid type of structure. It is probable that the large Pterodactyles of the same geological period, soaring like albatrosses and giant petrels over the Cretaceous seas, co-operated with the marine reptiles, as those sea birds now do with cetaceous mammals, in reducing the excessive numbers of the teeming tribes of fishes, and in maintaining the balance of oceanic life.

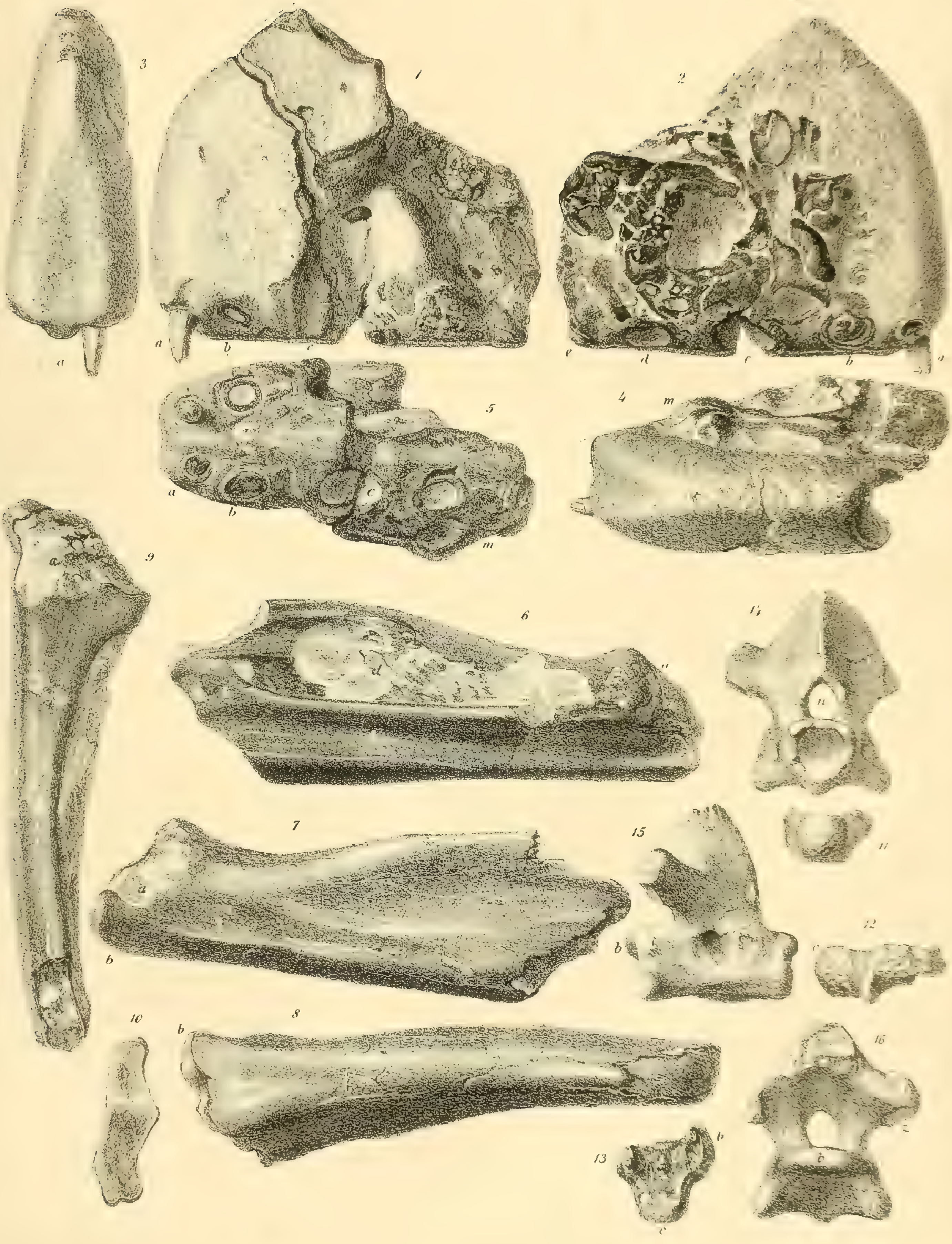
TAB. I.

Pterodactylus Simus.

Fig.

1. Fore part of the upper jaw, left side.
2. Ditto, right side.
3. Ditto, front view.
4. Ditto, upper view.
5. Ditto, under view.
6. Hind part of the right ramus of the lower jaw, inner side.
7. Ditto, outer side.
8. Ditto, under side.
9. Ditto, upper side.
10. Ditto, section.
11. Occipital condyle.
12. Basi-occipital, side view.
13. Ditto, upper view.
14. Atlas and axis vertebræ, front view.
15. Ditto, side view.
16. Ditto, back view.

The foregoing figures are of the natural size, and from specimens in the Woodwardian Museum of the University of Cambridge; they were obtained from the Upper Green-sand formation near that town.



Jos Dinkel lith

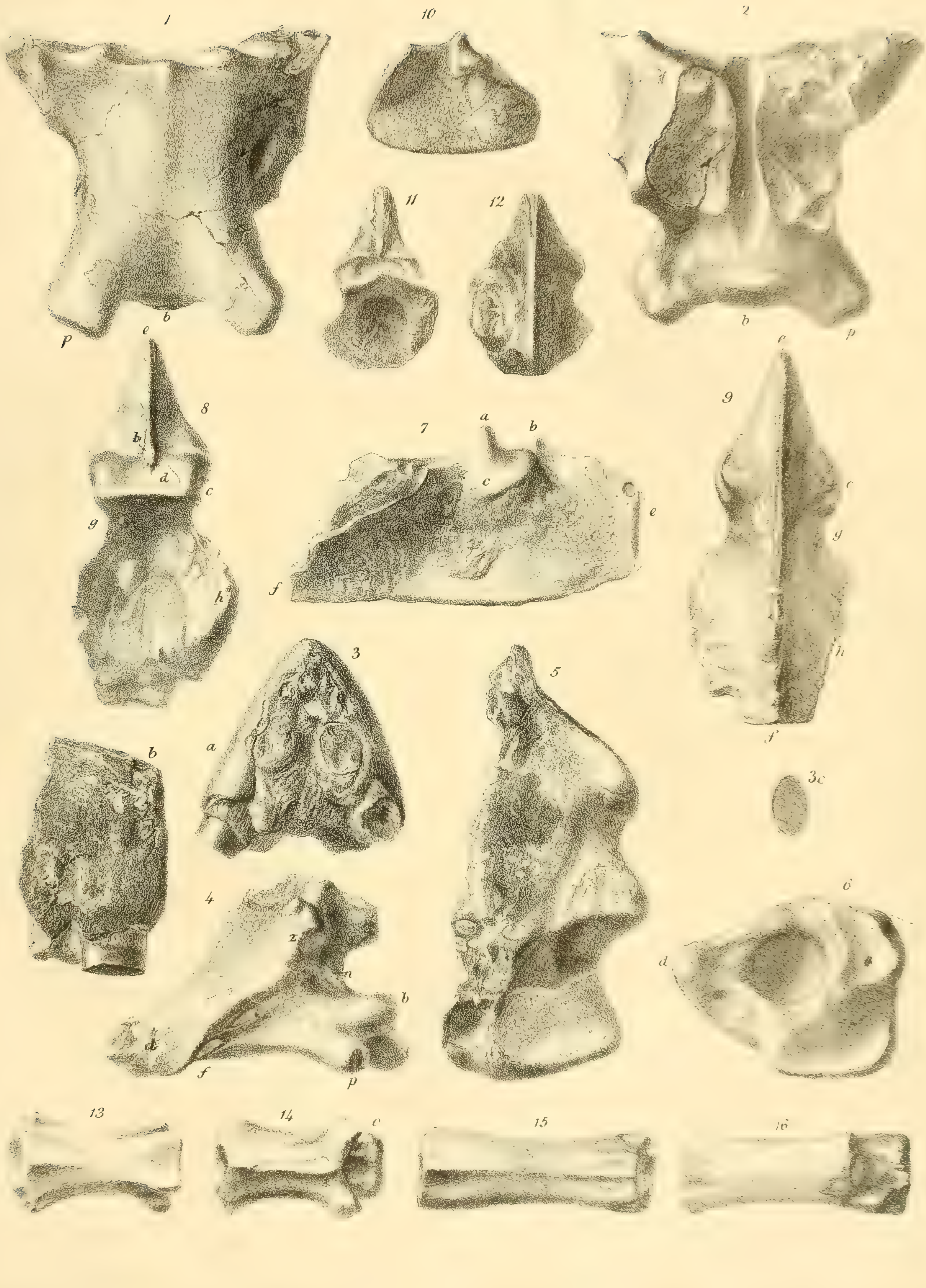
TAB. II.

Pterodactylus Simus and *Pter. Woodwardi.*

Fig.

1. Middle cervical vertebra, under view.
2. Ditto, upper view.
3. *a.* Fragment of jaw, section.
   b. Ditto, side view.
   c. Ditto, section of tooth.
4. Lower cervical vertebra, oblique view.
5. Glenoid articular cavity formed by the anchylosed ends of the scapula and coracoid.
6. Scapho-cuneiform (?) carpal bone.
7. Fore part of sternum, side view.
8. Ditto, upper view.
9. Ditto, under view.
10. Fore part of a smaller sternum, side view.
11. Ditto, upper view.
12. Ditto, under view.
13. Anterior caudal vertebra, under view.
14. Ditto, upper view.
15. Middle caudal vertebra, under view.
16. Ditto, upper view.

All the figures are of the natural size, and from specimens in the Woodwardian Museum of the University of Cambridge ; they were found in the Upper Green-sand formation near that town.



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TAB. III.

Humerus of Pterodactyle.

Fig.

1. Proximal or upper end of right humerus, oblique view of palmar and ulnar surfaces.
2. Ditto, anconal surface.
3. Ditto, palmar surface.
4. Proximal end of a left humerus, drawn without reversing, oblique view as in fig. 1.
5. Proximal end of a right humerus of a smaller species of *Pterodactyle*, oblique view as in figs. 1 and 4.
6. Proximal end of the right humerus of a bird (*Vultur monachus*), oblique view of palmar and ulnar surfaces.
7. Ditto, anconal surface.
8. Ditto, upper surface, or head.
9. Proximal end of the right humerus of a crocodile (*Crocodilus biporcatus*), oblique view of palmar and ulnar surfaces.
10. Ditto, anconal surface.
11. Ditto, oblique view of the palmar and radial surfaces.
12. Ditto, upper surface, or head.

All the foregoing figures are of the natural size; 1 and 3, probably of *Pterodactylus Cuvieri*, are from the White Chalk of Kent; 4, probably of *Pter. Sedgwickii*, and fig. 5, are from the Upper Green-sand formation, near Cambridge. The foregoing specimens are in the Woodwardian Museum of the University of Cambridge.

T. III.

TAB. IV.

Fig.

1. Upper view of a part of the cranium of ***Polyptychodon interruptus;*** one fourth the nat. size.

2. Fragment of the alveolar part of the same cranium; nat. size.

3. A tooth of the same specimen, side view, nat. size; *a,* ditto, opposite side; *b,* ditto, section of fang, showing pulp-cavity.

4. Basal half of a tooth of ***Pterodactylus simus;*** nat. size.

5. Unciform? carpal bone of ***Pterodactylus Sedgwickii***, proximal? surface.

6. Ditto, distal? surface.

7. Scapho-cuneiform? carpal bone of *Pterodactylus Sedgwickii,* proximal? surface.

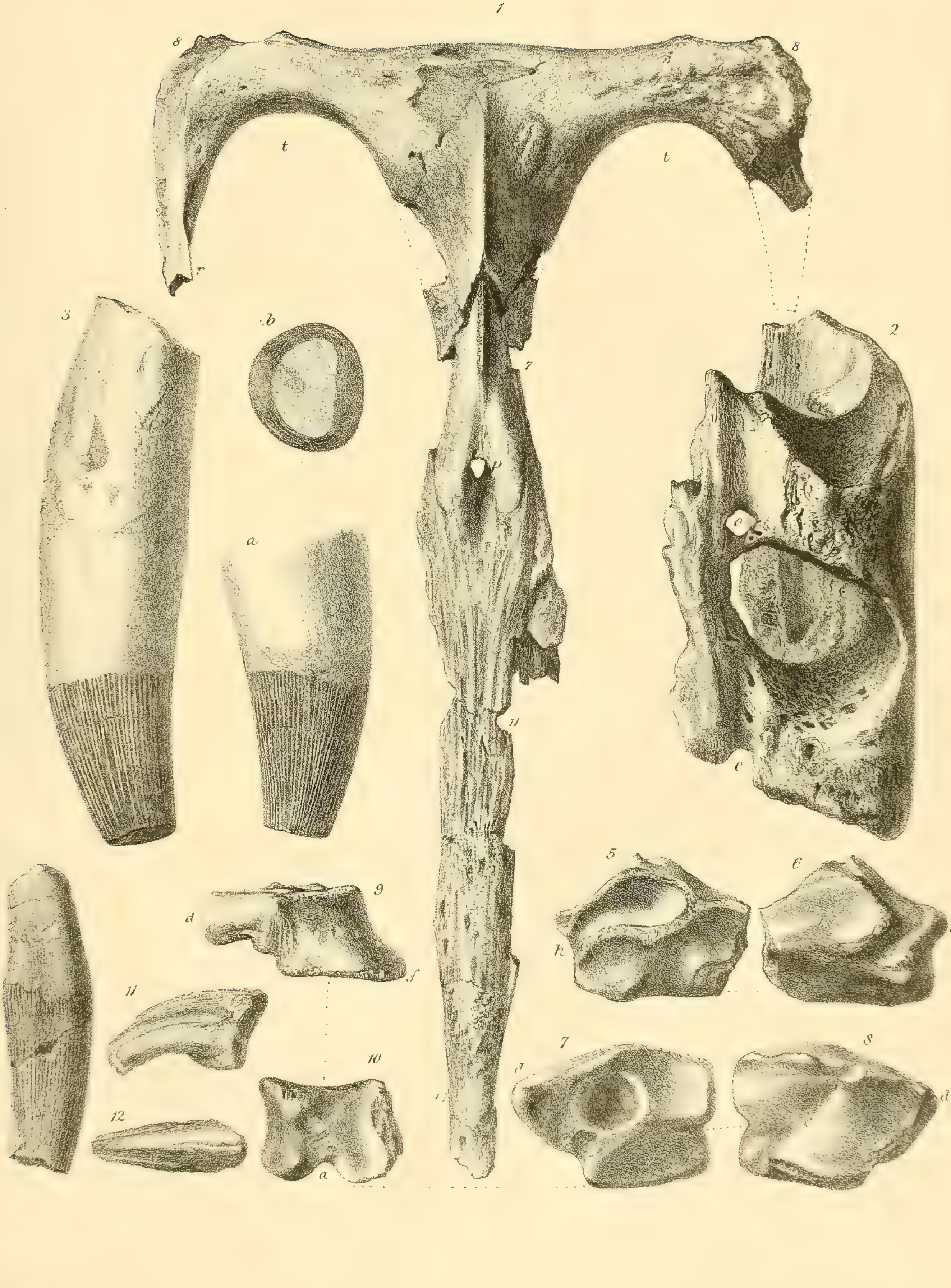
8. Ditto, distal? surface.

9. Ditto, side view.

10. Ditto, end view.

11. Ungual phalanx of ***Pterodactylus Sedgwickii,*** side view.

12. Ditto, upper view.



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TAB. V.

Polyptychodon interruptus.

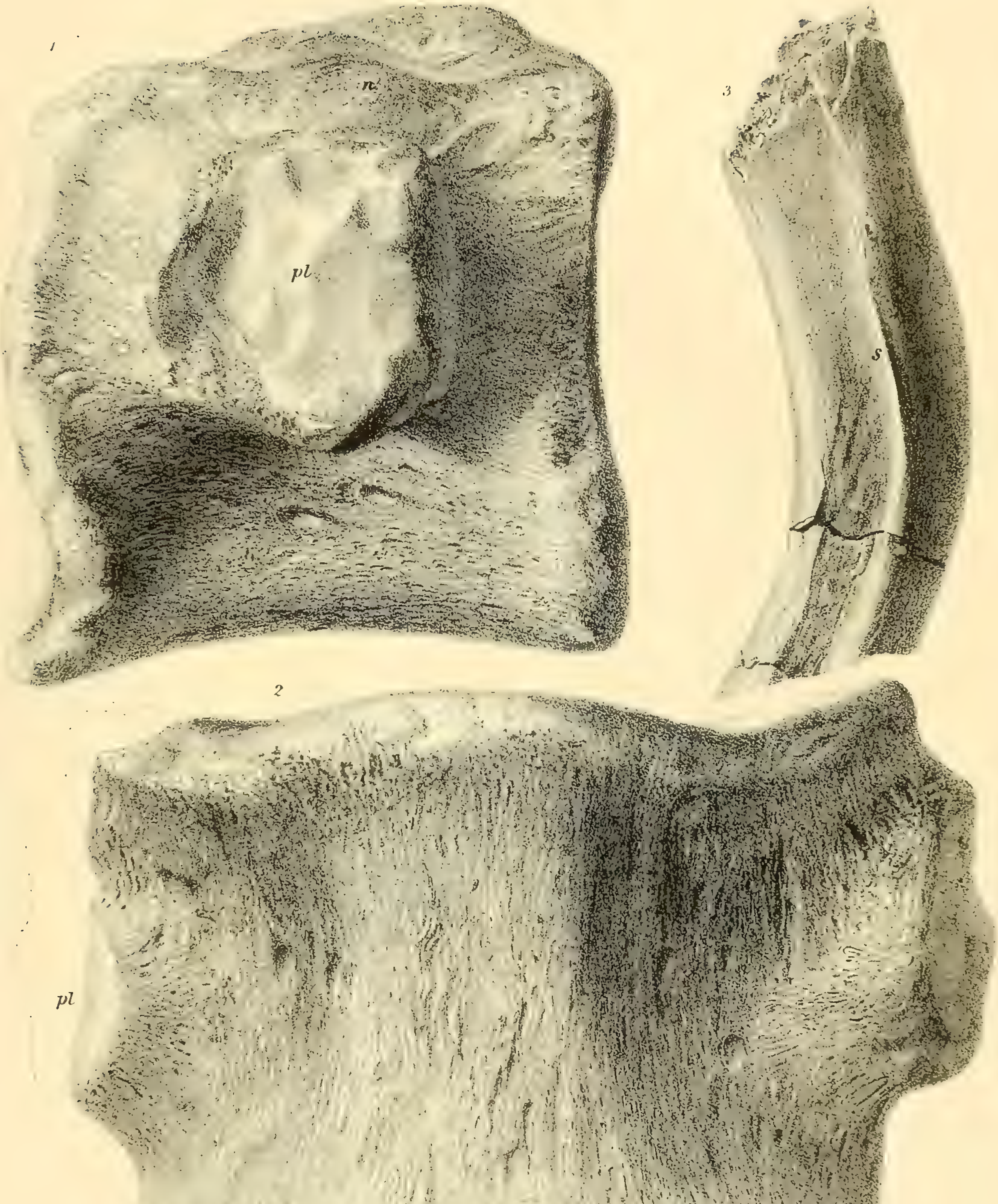
Fig.

1. Centrum of posterior cervical vertebra, side view.

2. Ditto, under view.

3. Fragment of a dorsal rib.

These figures, of the nat. size, are from specimens in the Woodwardian Museum of the University of Cambridge; and are from the Upper Green-sand formation near that town.



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TAB. VI.

Polyptychodon interruptus.

Fig.

1. Centrum of the atlas vertebra, front view.

2. Centrum of the axis vertebra, back view.

3. Anchylosed centrums of the atlas and axis vertebræ, upper view.

4. Ditto, side view.

These figures, of the nat. size, are from a specimen in the Woodwardian Museum of the University of Cambridge, discovered in the Upper Green-sand formation near that town.

1

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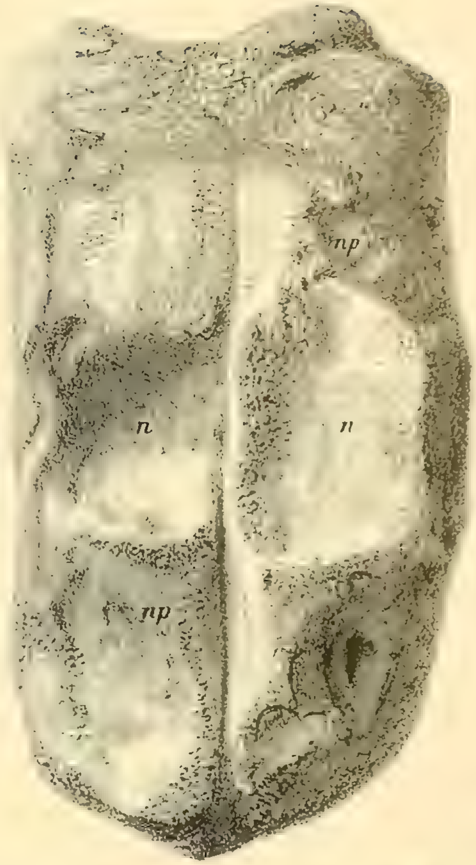

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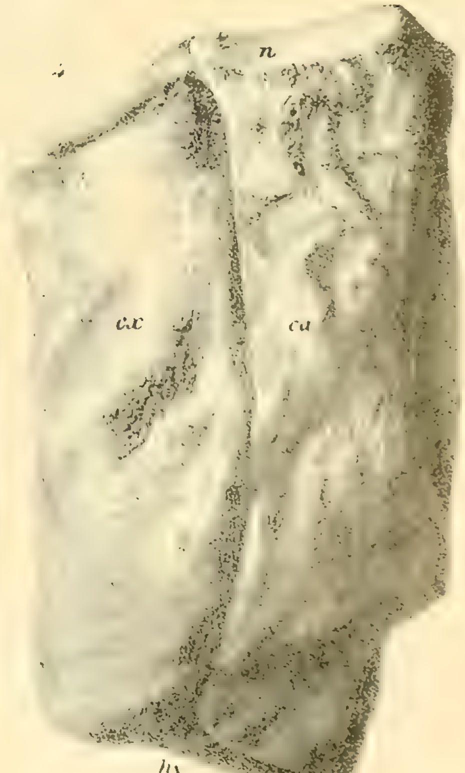

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

SUPPLEMENT No. IV.

Pages 1—18; Plates I—IX.

SAUROPTERYGIA (Plesiosaurus).

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1864.

SUPPLEMENT (No. IV)*

TO THE

MONOGRAPH

OF

THE FOSSIL REPTILIA

OF THE

CRETACEOUS FORMATIONS.

ORDER—SAUROPTERYGIA, *Owen.*

Genus—PLESIOSAURUS, *Conybeare.*

IN former Monographs and works are given descriptions of the following species of *Plesiosaurus* from Cretaceous deposits:

PLESIOSAURUS CONSTRICTUS, *Owen.* 'Dixon's Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, 1850, p. 398, pl. xxxvii, figs. 6 and 7. From Steyning Chalk-pit, Sussex.

PLESIOSAURUS BERNARDI, *Owen.* Op. cit., p. 396, pl. xxxvii, figs. 8, 9. From the Upper Chalk, Houghton Pit, near Arundel, Sussex.

PLESIOSAURUS PACHYOMUS, *Owen.* Monograph, Palæontographical Society, 4to, 1851, p. 64, tabs. xx, xxi. From the Upper Greensand at Reach, near Cambridge.

PLESIOSAURUS LATISPINUS, *Owen.* 'Descriptive Catalogue of the Fossil Remains of *Reptilia* and *Pisces* in the Museum of the Royal College of Surgeons of England,' 4to, 1854, p. 63, No. 251.

* This Memoir was given as 'Supplement No. II,' in the volume for 1862.

Plesiosaurus neocomiensis, *Cpche.* 'Description des Fossiles du Terrain Cretacé des Environs de Sainte-Croix,' 4to, 1858—1860, par N. J. Pictet and G. Campiche, p. 12, pl. vi.

The following are descriptions of other species of Cretaceous *Plesiosauri*, with additional illustrations of already indicated species:

Plesiosaurus planus, *Owen*. *Vertebral Centrums*, Tab. I, II, and III.

The cervical centrum selected for the figures 1—4, Tab. I, gives the characters afforded by this instructive part of the vertebral column of a *Plesiosaurus*. The flatness, both of the under (fig. 4) and of the terminal articular surfaces (fig. 2), suggested the name distinguishing the species, or at least the vertebræ by which alone this cretaceous Plesiosaur has hitherto been exemplified. The costal surfaces (Tab. I, figs. 1, 2, and 4, *pl*) are of a narrow, oblong figure, formed, as it were, by truncation of the lower angles of the triangular centrum, of which the apex has been more broadly removed by the sections, leaving the neural (ib., *n*) and neurapophysial (*np*) surfaces above. If the borders of the costal surface have projected with a sharper definition, they have been abraded, as, indeed, is most probable; almost all the bones derived from the stratum of Cambridgeshire phosphatic Greensand being more or less rubbed or worn, either in the original imbedding, or subsequently by the mechanical appliances by which the phosphatic nodules are extracted. I have selected the centrum which has been least subject to this attrition, from a large series of the present species. Subsequent observers, who may have been favoured with entire and unworn fossil vertebræ with the main features and proportions of the *Plesiosaurus planus*, will make allowance for the circumstances in which the materials for reconstructing that species first came to hand.

What may be more certainly predicated of the costal surface is the absence of depth and of linear horizontal bisection, both which characters are present in the cervicals of some other *Plesiosauri*. The distance between the costal and neurapophysial surfaces is nearly three times that of the vertical diameter of the former, and the intervening non-articular surface is smooth, and also plane or flat, sloping upward towards the neurapophysial border, and showing no sinking or concavity in the longitudinal direction. The neural surface, $2\frac{1}{2}$ lines in breadth at the narrowest part, slightly expands towards the posterior surface of the centrum. The neurapophysial surfaces are coextensive with the long or fore-and-aft diameter of the centrum, and of nearly equal breadth anteriorly; they are smooth and very shallow, with a slightly defined, thin border, which is undulated outwardly, descend-

ing lower upon the fore than upon the hind half of the centrum, and giving, in the pair, a contour somewhat like that of a saddle; I do not, however, insist upon this as a constant character of the cervicals of this species. In the present vertebra one of the venous orifices is larger than the other; but in a second, of similar size and contiguous position, they show the usual equality. The flatness of the terminal surfaces is remarkable, and betokens restriction of the movements of the neck of the species. On the similarly flattened under surface the venous foramina (fig. 4, *v*) open nearer the anterior than the posterior border.

In a cervical vertebra, of similar size and proportions, the neurapophysial surfaces are more concave in the longitudinal direction. As the cervical series approach the back the centrums increase in length, while preserving about the same relative breadth. In the vertebra, figs. 5—7, the costal surface (*pl*) has risen to the neurapophysial one (*np*), with which it has become confluent; the inferior tract of the centrum now describes a convexity between the two costal surfaces, though it is but slight; the contour of the terminal surface accordingly presents the form of a transversely elongate ellipse (fig. 6). The fore-and-aft contour of the under surface is very slightly concave, almost flat. The posterior border of the costal surface is produced, forming the beginning of a parapophysis (fig. 7). The neurapophysial surfaces are slightly excavated, with a defined but hardly raised border; they are undulated, smooth, with scattered foramina; their breadth is now one third more than their length. In the posterior cervical (fig. 7) the venous canals on the neural surface show the same inequality as in fig. 3.

In the vertebra in which the costal surface has wholly passed upon the neurapophysis (fig. 10, *np*), and which, from the proportions of length to breadth, is to be reckoned as coming from the beginning of the dorsal series, the sides of the centrum are excavated under the neurapophysial surfaces; but below the excavation, which is not deep, the longitudinal contour is as nearly straight as in the antecedent vertebra.

To one of the terminal surfaces of this vertebra (fig. 11) adheres the remnant of the lower valve of the spondyloid shell—*Dianchora striata*: the living *Spondylus Gussoni*, which most resembles the characteristic Green-sand bivalve, dwells at great depths in coral-beds of the Mediterranean. We may conceive, by analogy, that the carcass of the dead Plesiosaur, sinking and decomposing in a similar chalky manufactory, left its scattered bones to serve as the resting-places of those bivalves of its locality and period which, like the modern smooth and spiny oysters, anchor themselves for life after a brief locomotive period.

Towards the middle region of the back the centrums gain in vertical diameter, and somewhat in length, with a diminution of their transverse diameter. The concavity of the non-articular surface from before backward is still greatest near the neurapophysis, but has less the aspect of a circumscribed depression than in

the anterior vertebra. The neurapophysial pits now diminish in breadth, preserving their length nearly coequal with that of the centrum itself. The terminal articular surfaces show a slight sinuosity, feebly concave, with a less convexity at the middle part. The under surface still retains an aspect of flatness, both from before backward and from side to side. Most of these mid-dorsal vertebræ show a slight difference of length in the two sides, as in figs. 9 and 14.

In one dorsal vertebra (fig. 26) a terminal articular surface, showing a porous or spongy character, is also marked by irregular grooves converging toward the centre, like the corresponding surface of a Cetaceous vertebra from which the epiphysial plate had become attached. Save in this single instance, I never met with such an appearance in a Plesiosaurian vertebra; the opposite surface is smooth, as are both surfaces in the other vertebræ of *Pl. planus.*

In the tail the broad and short proportions of the vertebral centrum are resumed (figs. 16—19), but with a more marked concavity of the terminal articular surfaces, which in one vertebra showed fine lines radiating from the centre. A broad, but almost flattened, border extends from the terminal surface upon the side of the centrum, joining the costal surface, and expanding to mark the place and extent of attachment of the hæmapophyses. The diminished size and feebler impression of the neurapophyses bespeak the reduction of the neural arch at this part of the vertebral column. The pleurapophyses retain their independency, and were articulated to a small subcircular surface on the upper half of the side of the centrum; the lower half is almost flat, and joins, at an open angle, the equally flat, broad under surface, which is bordered, like the sides, by the deflected tract from the articular ends. The venous canals open upon the middle of the under surface, about four lines apart.

A few small vertebral centrums belonging to the present series, and apparently from a similar-sized Plesiosaur, if not part of the same individual, seem to be reduced to the simplicity of supporting only neurapophyses, and show no distinct marks of articulations for either pleur- or hæm- apophyses. The centrums are broad, depressed, with perfectly flat terminal surfaces, and a flattened under surface. They may come from the beginning of the neck, or from the end of the tail. I reject the latter notion, because the analogy of the terminal caudal vertebræ, or those in which the hæmapophyses ceased to exist, in other *Plesiosauri*, would lead one to expect a concavity of the articular surfaces, and a diminution in the lateral rather than in the vertical direction, a compressed rather than a depressed form. Assuming, then, that these vertebræ are from the beginning of the neck, the question next arises whether pleurapophyses were wholly absent, or whether they were so small and so feebly articulated as to leave no sign of their attachment, at least after the degree, slight as it is, of superficial abrasion to which the fossils have been subject. I think the latter condition may be the more

probable one, although in some species of ***Plesiosaurus***, as *e.g.* the present, the "hatchet bones" or cervical ribs might only commence on the third or fourth vertebra, beyond the coalesced atlas and axis. As a general rule, they begin on the second cervical.

Thus, the characters of the *Plesiosaurus planus* are exemplified, so far as they are shown by the vertebral centres, from all the chief regions or parts of that column. The majority of the vertebræ which have served for the comparisons and illustrations leading to the above-given information as to the species, have been kindly confided to me for that purpose by the Rev. Adam Sedgwick, F.R.S., Woodwardian Professor in the University of Cambridge.

These vertebræ differ from those of all the previously described species of Cretaceous Plesiosaurs in the proportions of breadth to length, especially in the cervical region, and in the flatness of the terminal articular and of some other surfaces of the centrum.

Several larger vertebræ have reached me singly, as though from a more scattered disposition of parts of the dislocated skeleton in the phosphatic Greensand bed of Cambridgeshire, which agree in character with the *Plesiosaurus planus.*

In the *Plesiosaurus pachyomus* the centrum increases in breadth as it approaches the back, whilst some of the dorsal vertebræ offer almost the same proportions as those in the above-described series.

But the difference in the corresponding cervical vertebræ is very striking, as is exemplified in the following comparative admeasurements.

Admeasurements of vertebral centrum :—

	Anterior cervical.		Middle cervical.	
	Pl. pachyomus.	*Pl. planus.*	*Pl. pachyomus.*	*Pl. planus.*
	In. lines.	In. lines.	In. lines.	In. lines.
Antero-posterior diameter or length .	1 9	0 11	2 0	1 3
Transverse diameter or breadth .	2 3	1 10	2 3	1 5
Vertical diameter or height . .	1 9	1 1	2 3	1 3

The centrum (Tab. II, figs. 1 and 2) is of a vertebra from the posterior part of the neck. The anterior articular surface presents a transversely elongate elliptical form (fig. 1), contrasting with the almost circular contour of the same part in *Plesiosaurus pachyomus* (Monogr. 1851, Tab. XX, fig. 2). It is very slightly, but uniformly, concave. The neurapophysial pits (fig. 2, *np*), of a triangular form, and coextensive with the fore-and-aft extent of the centrum, are divided by a neural canal (fig. 2, *n*), of about 4 lines in breadth, and their lower angle, which is rounded off, projects from the side of the centrum, which is not the case in *Plesiosaurus pachyomus*. The costal pit (Tab. I, fig. 1, *pl*) is much smaller than in *Plesiosaurus*

pachyomus (l. c., Tab. XX, fig. 1, *pl*). The under surface of the centrum is flat from before backward, and describes a gentle uniform convexity from one costal pit to the other.

The vertebral centrum, Tab. II, figs. 3, 4, 5, is from the base of the neck, and from a larger individual. The bases of the neurapophysial pits (fig. 4, *np*) have not been coextended with the increased length of the centrum, and the apex contracts more quickly, and is extended to the upper division of the costal pit. The breadth of the neural surface (ib., *n*) is the same as in the more anterior cervical centrum (fig. 2); but the orifices of the venous canals are more conspicuous. Only a small part of the costal pit (ib., *pl*) now marks the centrum; it projects from the side of that element, nearer its posterior surface. The articular surfaces of the centrum (ib., fig. 3, *c*) are nearly flat, and slightly undulating, without a central pit. The lower orifices of the venous canal are about two lines apart.

The centrum, Tab. II, figs. 6—9, is from the base of the neck of another and larger individual of the *Plesiosaurus planus,* and, with a moderate increase of all its dimensions, shows least that of breadth. The articular surface of the centrum (fig. 6, *c*) has a shallow depression at its middle part, occupying about half the breadth of the surface; it is flat at the circumference, and its margin, though obtuse, is narrow and well defined. The narrow outer part of the neurapophysial tract (ib., fig. 9, *np*) has a well-defined raised border, terminating in the major part of the costal surface, the lower half of which is much reduced in size; the interspace is occupied by a small mass of matrix. The under surface shows a slight concavity from before backward. The non-articular surface of the centrum is almost smooth.

A similar and closely succeeding vertebral centrum of the same species of *Plesiosaurus* is figured in Tab. III, figs. 5 and 6. It is more mutilated, and a portion of a rib is cemented to the neural surface (fig. 6). The costal surface has risen wholly upon the neurapophysis (*np*), the base of which adheres to the centrum, and projects outward as a costal diapophysis (*d*). This centrum is from the fore part of the dorsal region.

The cervical centrum (Tab. III, figs. 1—4) appears to have come from the basal third of the neck, perhaps from the beginning of that part, in which the contour of the articular surface, expanding towards the lower part, takes on, as in the antecedent cervicals (Tab. I, fig. 2), something of a triangular form; here, however, the shape of the neurapophysial surfaces (*np*) is of a more regular triangular form (compared with fig. 2, Tab. II) and they are connected by a narrow, slightly elevated tract with the costal pit (*pl*). This articular surface begins to diminish in antero-posterior extent, indicating a corresponding change in the shape of the shaft of the costal rib; the terminal articular surface of the centrum has a slight central

depression, of the same relative extent as in fig. 6, Tab. II. The under surface (Tab. III, fig. 4) is almost flat, both lengthwise and transversely; the venous outlets present the same relative position, and the non-articular surface of the centrum shows the same degree of smoothness and flatness as in the smaller vertebræ (Tab. I, figs. 2, 6). The present centrum belongs to the same species of *Plesiosaurus* as those of the more regular elliptical form, and is merely indicative of a different position in the region of the neck.

A centrum with the surface much abraded (Tab. III, fig. 8) appears to have presented the same inferior expansion, and consequent triangular form, as fig. 1; but in the under surface (fig. 9) the venous canals have opened into well-marked depressions. Other differences, as in the character of the neurapophysial surfaces (fig. 7, *np*), may be due to the degree of abrasion to which the present fossil has been subject.

PLESIOSAURUS BERNARDI, *Owen*. *Cervical Vertebræ*. Tab. IV.

In my 'Monograph of the Fossil Reptilia of the Cretaceous Formations,' Volume of the Palæontographical Society for 1851, p. 60, I characterised a species of *Plesiosaurus* from a cervical vertebra then in the museum of my esteemed friend, FREDERIC DIXON, Esq., of Worthing, under the name of *Plesiosaurus Bernardi*, which vertebra was figured in Plate XVIII of the above-cited Monograph. I have subsequently had the opportunity of examining several other vertebræ of a *Plesiosaurus* from the Green-sand of Reach, near Cambridge, which are referable to the same species, but most of them to an individual of smaller size, and probably of immature age.

The specimen (Tab. IV, figs. 1, 2, 3, 4) is an anterior cervical vertebra, which agrees with the more posterior one above figured in the degree of concavity of the articular surfaces of the centrum, in the extent of the peripheral border of that cavity, which is convexly bevelled off ("évasé"), and in the relative position of the neur- and pleur-apophyses; the breadth of the centrum is not so much greater proportionally to the length; but this difference I believe to be due to the more anterior position in the vertebral series from which the present specimen has been derived.

The neurapophysial depression (*np*) is deep and smooth, encroaching further on the convex border of the centrum at its back than at its fore part; they are divided at the upper surface of the centrum by a neural tract (fig. 3, *n*), about 2 lines broad at its narrowest part. The non-articular surface of the centrum is moderately smooth, especially at the sides between the neur- (*np*) and pleur- (*pl*)

apophysial pits, (fig. 1); its vertical extent here is not quite equal to that of the pleurapophysial pit. This is of an oblong oval shape, less deeply concave than the neurapophysial pit, with a smooth surface, nearer the posterior than the anterior surface of the vertebra, with the border slightly prominent (fig. 4, *pl*). The venous foramina at the lower surface (fig. 4) are situated in depressions, divided by a ridge-like narrow tract of the centrum. In this character, but more especially in the depth of the terminal articular surfaces, with their broad and thick convex border, and in the position of the riblet, the present centrum is referable to the *Plesiosaurus Bernardi*.

The following are dimensions of this cervical centrum:

	Pl. Bernardi. In.	lines.
Antero-posterior diameter or length	1	2
Transverse diameter or breadth	1	4
Vertical diameter or height	1	4

The centrum, Tab. IV, figs. 5 and 6, appears to have succeeded the foregoing in the same cervical series, with, perhaps, the intervention of one or two vertebræ. It is similar in colour and mineral character, and from the same locality. It repeats the distinctive characters of *Plesiosaurus Bernardi*. It indicates by a slight obliquity the effects of posthumous pressure.

This mechanical force has distorted in a greater degree a centrum (Tab. IV, figs. 7 and 8), doubtless from a more posterior part of the same neck. The margins of the pleurapophysial pits are here rather more produced. The middle of the deep concavity of the terminal surfaces is impressed by a transverse pit or linear mark (fig. 8).

Col. Kiprianoff, of the Imperial Russian Engineer Corps, submitted to me some plesiosaurian vertebræ from the Neocomian deposits, or Green-sand, of Kursk, in the district of Kursk, near Moscow, which offered all the characters of the *Plesiosaurus Bernardi*. A cervical vertebra, intermediate in size between figs. 6 and 7, shows a partial anchylosis to the centrum of both neur- and pleur- apophyses. The riblet was confluent to a surface near the lower part of the centrum, about the same distance from the neurapophysis as in the first-described vertebra (fig. 1) from the Cambridge Green-sand. The under surface was ridged or pinched up, as it were, between the venous foramina, each of which was also situated in a depression between the median ridge and the base of the riblet. This element expanded, and its posterior angle was produced backward. The following were the dimensions of the centrum of this vertebra:

	Plesiosaurus Bernardi.	
	In.	lines.
Antero-posterior diameter or length	1	3
Transverse diameter or breadth	1	7
Vertical diameter or height	1	4

In a more posterior cervical vertebra, from the same Russian locality, the terminal articular surfaces are deeper towards the centre, with the out-turned or "évasé" borders very thick. The base of the neurapophysis was here also partially anchylosed, and the rib more completely so; it presented a rhomboid form, being inclined backward as well as outward, with the anterior angle rounded, and the posterior one produced. The inferior medial ridge was well marked. The breadth of the centrum was relatively greater than in the preceding vertebra.

In the vertebræ from the Cambridge Green-sand (Tab. IV, figs. 9 and 10), which have succeeded one another from about the same part of the neck, anchylosis of the pleurapophysis has not been completed; but that of the neurapophysis (*np*) has been so to a degree sufficient for preserving their base in connection with the centrum, although the summit has undergone fracture. The line of suture is, however, very distinct.

The terminal surface of the centrum presents the same degree of concavity, with a slight central horizontal linear depression, Tab. V, fig. 1, as shown in Tab. IV, fig. 8. The base of the neurapophysis (*np*) extends to the anterior margin of the centrum, but not quite to the posterior one. The outer surface of the neurapophysis presents a low obtuse ridge or rising, extending from near the infero-posterior angle to the outer side of the prezygapophysis (Tab. IV, figs. 9, 10, 11, *z*); the aspect of the articular surface of this process is obliquely upward and inward. The posterior border of the neurapophysis is thicker, or more obtuse, than the anterior one; the internal surface is smooth and even. Rather less than the vertical diameter of the pleurapophysial pit (figs. 10 and 11, *pl*) intervenes between it and the base of the neurapophysis (*np*). The inferior surface of the centrum presents the ridge between the two depressions into which the venous vertical canals open.

In the vertebra (Tab. IV, fig. 11), from a more posterior part of the neck, or from a larger *Plesiosaurus,* a greater proportion of the neural arch (*np*) is preserved, partially anchylosed to the centrum; the sides are strengthened by the same oblique thickening, extending to the prezygapophysis (*z*); this is larger than the postzygapophysis (*z′*), and the breadth of the arch across the prezygapophyses is nearly twice that across the posterior pair (Tab. V, fig. 6). The neural spine appears to have been a thin plate; its base (Tab. V, fig. 6) extends from the notch between the postzygapophyses (*z′*) to within 3 lines of that between the prezygapophyses (*z*). This vertebra has been compressed laterally, and rather obliquely, by posthumous pressure; yet under such general support that the neural arch,

though apparently narrowed from side to side is not broken; the neural canal (Tab. V, fig. 2, *n*) presents a vertical diameter of 11 lines, and a transverse diameter of 7 lines. The costal depression (Tab. IV, fig. 11, *pl*) extends nearer to the posterior than to the anterior surface of the centrum. The articular surfaces of the centrum show the characteristic depth of the concavity, but with relatively less thick obtuse borders, Tab. V, fig. 2.

The dimensions of this vertebra are:

	In.	lines.
Length of centrum	1	7
Height of ditto	2	0
Breadth of hinder surface of ditto	1	11
From base of neurapophysis to end of postzygapophysis	2	3
From end of pre- to that of postzygapophyses	2	3
Breadth of neural arch across prezygapophyses	2	0
,, ,, ,, ,, ,, postzygapophyses	1	1
Antero-posterior extent of base of neural spine	1	4

The vertebra, Tab. V, figs. 3, 4, and 5, appears to have come from the middle of the neck of an older and larger *Plesiosaurus*, and it displays, in a striking degree, the characteristics of that part of the *Plesiosaurus Bernardi*.

The depth of the concavity of the terminal surfaces of the centrum is almost ichthyosaurian; the breadth of the convex border of each cavity is extreme, and is equally divided between the smoother articular surface continuous with that of the concavity, and the surface roughened by fine concentric linear impressions, forming the outer part of the border, and indicative of the strong circular ligaments which tied the vertebræ together.

Anchylosis of both neur- and pleur-apophyses is here complete; and the missing parts of both vertebral elements have been broken off. The neurapophysial suture is, however, traceable; and the characteristic distance between it and the cervical rib is thus exemplified. The rising between the vascular depressions on the under part of the centrum (fig. 4) is broader and less ridge-like than in the more advanced vertebræ of the neck. In this vertebra, in relation to its more posterior position in the neck, the transverse diameter has increased upon the longitudinal one, as is shown in the following admeasurements:

	In.	lines.
Length of centrum	1	9
Breadth of ditto, posterior surface	2	6

The riblet, at its fractured surface (fig. 5, *pl*), shows an antero-posterior diameter of 10 lines, a vertical diameter of 5 lines.

Valves of the fry, or young, of a species of *Plicatula* (?) adhere to this fossil, to which they attached themselves at the period when the cretaceous beds,

receiving the carcases of the dead *Plesiosauri,* were still in process of formation, where now the dry land of Cambridgeshire has risen.

In a dorsal vertebra of this species, from the Neocomian deposits of Kursk, the terminal articular surfaces of the centrum were less concave than in the neck, and the lower surface was obscurely or very obtusely ridged. This vertebra measured in :—

	In.	lines.
Length	1	9
Breadth, anterior surface of centrum	2	6
" posterior surface of centrum	2	8

A caudal vertebra of the same species of *Plesiosaurus,* from the same formation and locality, showed the hæmapophysial surface best marked on the posterior border of the centrum; they were each subtriangular in shape, 6 lines in long diameter, and 1 inch apart. The pleurapophyses were anchylosed to the upper part of the centrum, or over the base of the neurapophysis; but the sutural line of juncture could be traced. The terminal surfaces of the centrum were moderately and gradually concave, but with the broad obtuse border. The lower surface was nearly flat and subquadrate, with only a feeble indication of a rising between two small venous foramina. The length of this vertebra was 1 inch 7 lines, the breadth of the centrum was 2 inches 3 lines.

I have introduced the above notices of the vertebræ of the *Plesiosaurus Bernardi* from the Green-sand beds of the neighbourhood of Moscow, in illustration of the geographical range of the species at the period of geological time in which it existed; this period extending from the "neocomian" to the "upper chalk" of the Cretaceous series. In the following section will be found a similar illustration of the geographical range of another Cretaceous Plesiosaur.

Plesiosaurus neocomiensis, *Campiche. Cervical and dorsal vertebræ; humerus and femur.* Plate VI.

Professor Pictet and Dr. Campiche, in their excellent 'Description des Fossiles du Terrain Crétacé des Environs de Sainte-Croix,' 4to, 1858—1860, have described and figured three centrums of a dorsal vertebra of a *Plesiosaurus,* to which Dr. Campiche has attached the name *neocomiensis,* inasmuch as these fossils were derived from the lower neocomian or "valanginian" beds of the Cretaceous deposits described in the above work. And this name, although there be other neocomian Plesiosaurs, and there may be many, I retain for a species, richly illustrated, from the Upper Green-sand deposits of Cambridgeshire, and which I believe to be identical with Dr. Campiche's.

Dorsal centrums are usually the least significant of specific characters, owing to the limitation of the articular surfaces to the neurapophysial and terminal ones, and also owing to a resumption, more or less, in the dorsal region of the more common proportions of the centrum, when this is departed from, either in excess of breadth, depth, or shortness, in the cervical region.

Dr. Campiche's description is so minute and exact that the correspondence of the dorsal centrum (Tab. VI, figs. 9, 10, 11) with the characters expressed at p. 43, op. cit., and shown in "Plate VI" of that work, will be found to justify the specific approximation. The centrum of *Pl. neocomiensis* is "a little broader than high, so that the articular surfaces form nearly a transverse, very slightly elongated, ellipse; the shape would be even better expressed by a circle, of which the upper part was flattened and subtruncate (see fig. 18)."* "The length is sensibly inferior to the two other dimensions; the sides are strongly and gradually excavated, so that when the vertebra is viewed from above," (as in fig. 11, Tab. VI) op. cit., "its middle part is much narrower than its articular surfaces. The inferior region, corresponding to the medial line of the body, is more feebly excavated.† The two large and deep neurapophysial pits are slightly arched inwardly, and are two and a half times as long as they are large; but the most significant character is the slight concavity of the terminal surfaces, with their middle part feebly raised into an irregular protuberance."

In the larger of the dorsal centrums from the Swiss Neocomian, measuring 2 inches 7 lines in transverse diameter, the median rising is 10 lines in diameter, but not more prominent than the more circumscribed rising in Tab. VI, fig. 10 of the present Monograph. In the smaller Swiss centrum (Plate VI, fig. 2 of op. cit.) the central eminence is broader and lower than in the nearly equal-sized centrum (Tab. VI, fig. 10) of the present Monograph; nevertheless, I am inclined to think that the mammillate character of the terminal articular surfaces shown in the cervical vertebræ may, like other characteristic modifications, be less strongly manifested in the dorsal vertebræ, or in some of the dorsal vertebræ of the same individual; and, therefore, I supersede my MS. denomination of *Plesiosaurus mamillatus*, under which I distinguished those vertebræ from the Cambridge Green-sand, when first obtained

* "Un peu plus larges qu'ils ne sont hauts, en sorte, que leurs faces articulaires forment, à peu près, une ellipse transverse très peu allongée. Leur forme serait même mieux exprimée par un cercle dont la partie supérieure serait aplatie et subtronquée."—Op. cit., p. 43.

† "La longeur est sensiblement inférieure aux deux autres dimensions. Les flancs sont fortement et graduellement excavés, en sorte que, lorsqu'on regarde la vertèbre au dessus, sa partie médiane est beaucoup plus étroite que les faces articulairés." "La région inférieure qui correspond à la ligne médiane des corps est beaucoup plus faiblement infléchée. A la face supérieure, on voit deux grandes et profondes impressions, correspondant à l'insertion des neurapophyses ou lames tectrices. Elles sont un peu arquées en dedans, deux fois et demie aussi longues que larges, les faces articulaires sont légèrement concaves, avec leur milieu faiblement relevé en une protubérance irrégulière."—Op. cit., p. 43.

for the British Museum, and adopt Mr. Campiche's name, which has the priority of publication, under the conviction of the specific identity of the vertebræ from the two localities.

All the mamillate vertebræ I have yet seen from the Cambridge Green-sand indicate a Plesiosaurus not larger than that represented by the smallest of the dorsal centrums from St. Croix.

The cervical vertebræ (Tab. VI, figs. 1—4) shows a greater proportional transverse dimension of the centrum than in the vertebra from the dorsal region (ib., figs. 9, 10), the sides of the centrum are less concave (compare fig. 4 with fig. 11); on the inferior surface the shallow impressions into which the vertical venous canals open, are divided by a narrow ridge-like tract (ib., fig. 4). The neurapophysial depressions (figs. 1 and 3, *np*) are broader than in the dorsal centrum, are of a triangular form, and, as the intervening neural tract is of equal breadth (ib., fig. 3), it is relatively larger than in the dorsal vertebra (ib., fig. 11); the venous foramina in this tract (fig. 3, *n*) are also wider apart. The costal surface (fig. 1, *pl*) is large in proportion to the centrum, well defined, but not deep; transversely elliptic; 9 lines in longitudinal by 6 lines in vertical diameter, and 3 lines distant from the apex of the neurapophysial pit (*np*): it is situated rather nearer the posterior than the anterior part of the centrum, and its margin slightly projects from the level of the non-articular surface of the centrum; the distance between the inferior borders of the two costal pits (fig. 4, *pl*) is 10 lines. The terminal articular surface (fig. 2) is less concave than in the *Plesiosaurus Bernardi*, and although obtuse and convex at the circumference, is less thick or tumid there; but the conspicuous and chief distinction is the well-defined mammillary eminence in the centre of each of the terminal concavities. The following are dimensions of this centrum:

	In.	lines.
Length	1	1
Breadth	1	5
Depth	1	4

Figures 5 and 6 represent a vertebra of apparently the same individual from the base of the neck, where the costal surface (Tab. VI, fig. 5, *pl*) has almost wholly ascended from the centrum upon the neurapophysis (*np*), and is more prominent than in the average cervical vertebræ. The under surface of the vertebra is not excavated or ridged, and is very slightly concave lengthwise; it resembles that of the average dorsal vertebræ. The mamillate character of the terminal articular surface is as well marked as in the average cervical vertebræ.

Figures 7 and 8 are of a posterior cervical vertebra of another individual, from a different locality, in which the centrum is relatively shorter than in the two fore-

going vertebræ; in other respects the characters closely accord with those of the posterior cervical centrum (figs. 5 and 6), and I regard the present as indicating a mere variety in the proportions of the centrum, which is also less than it appears in the plate, on account of the abrasion of the circumference of one of the terminal articular surfaces.

The dimensions of the restored centrum are:

	In.	lines.
Length	1	3
Breadth of posterior surface	1	8
Height	1	6

The dorsal centrum (figs. 9, 10, 11) exhibits the characters already specified in the comparison of it with the type-vertebra of Dr. Campiche's species; the chief or sole difference is the more circumscribed and smaller circumference of the central mamilla of the terminal articular surface; the neurapophysial pits have undergone the change of form and proportions which brings them to the same pattern as in the dorsal vertebræ figured in the 'Paléontologie Suisse,' loc. cit.

In the locality whence the specimens (figs. 1—6, 9—11, Tab. VI) were exhumed, some portions of limb-bones were obtained of a *Plesiosaurus* of corresponding size, of which I select for figuring a left femur (fig. 12) and the lower two thirds of a left humerus (fig. 13). The outline of a section through the broadest part of the distal and of the humerus is given to the left of fig. 13, to exemplify the difference in the proportions of this bone from the humerus of the *Plesiosaurus pachyomus* from deposits of the same age. The outline connected by dots with fig. 12 represents a section of the proximal end of that femur. I think it most probable that both these bones appertain to the *Plesiosaurus neocomiensis* of Campiche.

Plesiosaurus latispinus, *Owen*. Cervical vertebræ, Tab. VII; cervical and dorsal vertebræ, Tab. VIII; ilium and coracoid, Tab. IX.

This species was founded on the characters of the two cervical vertebræ figured in Tabs. VII and VIII. They form part of a scattered series of about a dozen vertebræ, with ribs, scapulæ, portions of the coracoid bones (Tab. IX, fig. 2), an ilium (Tab. IX, fig. 1), and a few other parts of the skeleton, included in a rock of the "Shanklin-sand" or Lower Green-sand series, from the so-called "Iguanodon Quarry," at Maidstone, Kent, where they were observed and partially wrought out

by the proprietor, WILLIAM HARDING BENSTED, Esq., to whom the earlier discovery of remains of an Iguanodon in the same locality and formation, is due.*

My first knowledge of these remains was obtained from plaster casts of the two most complete vertebræ which were transmitted to me by Mr. Bensted for determination of the species in 1853, which casts were afterwards presented by Mr. Bensted to the Museum of the Royal College of Surgeons.† The original of these casts, with the other portions of the skeleton discovered by Mr. Binsted, have since been purchased by the Trustees of the British Museum.

From the *Plesiosaurus pachyomus,* Owen, of the Upper Green-sand of Cambridgeshire, the present species differs in the greater relative length and breadth of the centrum in proportion to its height, in the smaller relative size of the costal surface, its greater prominence, and inferior position upon the side of the centrum, where it is supported by a low parapophysis (compare Tab. VII with Tab. XX, tom. cit., Monogr. Cretaceous Reptiles). In that plate are represented the centrums of three cervical vertebræ of the *Plesiosaurus pachyomus;* one (fig. 1) giving the characters of the ordinary or more numerous cervicals; a second (fig. 2) showing the commencement of the rise of the costal surface, and the development of the vertical ridge connecting it with the neurapophysial surface; a third (fig. 3) showing the junction of the two articular surfaces indicative of the passage of part of the head of the pleurapophysis upon the base of the neurapophysis.

The following are dimensions of an ordinary cervical centrum of the two species:

	Plesiosaurus latispinus		*Plesiosaurus pachyomus.*	
	In.	lines.	In.	lines.
Length	2	8	1	11
Breadth	3	0	2	3
Height	2	6	2	3
Fore-and-aft diameter of the costal surface	1	0	1	4

The borders of the terminal articular surface are thinner and more defined in *Plesiosaurus latispinus* than in *Plesiosaurus pachyomus.* The costal surface (Tab. VII, fig. 1, *pl*) is longitudinally coextensive, in *Plesiosaurus latispinus,* with little more than one third of the fore-and-aft extent of the centrum. In *Plesiosaurus pachyomus* it is coextensive with two thirds of the same extent. In *Plesiosaurus latispinus* it is situated so low down as, in a direct side view, to mask part of the inferior contour of the centrum. In *Plesiosaurus pachyomus* it allows the whole of the lower contour to be seen in the same side view. In *Plesiosaurus latispinus* more than the vertical diameter of the costal surface, by one fifth or one sixth, intervenes between it

* See 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' volume of the Palæontographical Society for 1851, p. 105.

† See 'Descriptive Catalogue of the Fossil Reptilia and Pisces,' 4to, p. 63, No. 251.

and the neurapophysial surface. The terminal articular surface (ib., fig. 3) is very little concave, sububundulating, with a transversely elliptical, very shallow, central depression. The sides of the centrum are slightly concave, the under surface more feebly so, and it is not longitudinally ridged. The venous foramina are divided by a transversely convex tract of 6 lines extent (Tab. VII, fig. 2). The whole of the non-articular surface is smooth. The costal surfaces (fig. 1, *pl*) are almost wholly situated in the posterior half of the centrum. The neural arch and spine, by rare fortune, are preserved in the present instance (fig. 1) in natural articulation with the centrum. The sutural line describes a subangular convexity downwards, and with the lowest part (*np*) nearer the anterior surface of the centrum. The neurapophysis, as it rises, has its fore-and-aft extent decreased by emarginations, of which the posterior one is the longest; this extent then increases by the development of the zygapophyses, of which the posterior (z') is most raised; but the anterior (z) most produced. The spinous process (*ns*) is remarkable for its antero-posterior extent, preserving the same width to its truncated summit; it thus presents a subquadrate figure, and is inclined rather forward; it arises from the entire fore-and-aft extent of the median line of the neural arch. The total height of the vertebra, from the under part of the centrum to the summit of the spine, is 9 inches; the height of the spine itself is $4\frac{1}{2}$ inches; the antero-posterior diameter is $2\frac{1}{2}$ inches. The articular surfaces of the prezygapophyses (z') look upward and a little inward; those of the postzygapophyses (z) look in the opposite direction.

Two other cervical vertebræ, with the characters above defined, are preserved in the slabs of stone exhibiting the parts of the skeleton of the same individual Plesiosaur. In the last cervical vertebra (Tab. VIII, figs. 1 and 2) the costal surface is of large size, especially in the vertical direction, and is supported in its lower third upon a parapophysis (p), which has now risen to the middle of the side of the centrum, and has come in contact with a diapophysial development (d) of the side of the neural arch, supporting the upper two thirds of the costal surface. Together they form a thick and deep outstanding process, 2 inches in vertical by 1 inch 3 lines in transverse extent, with the articular surface for the expanded head of the rib looking outward and rather downward, fig. 2. The terminal articular surface of the centrum (fig. 2, c) presents a sharper or better defined border than that of the normal cervical vertebra (Tab. VII, fig. 3); it is 3 inches 6 lines in transverse, and 2 inches 8 lines in vertical diameter, almost an ellipse in figure, but with the lower curve greater or deeper than the upper one; the central shallow depression is continued in the present vertebra, of similar proportions and contour as in the foregoing normal cervical vertebra. The neural arch has become anchylosed to the centrum, but the greater part is broken away. The neural canal (n) is subcircular, 8 lines in diameter.

In the dorsal region, where the rib is supported wholly by a diapophysis developed from the platform of the neural arch (*np*), the centrum has assumed the ordinary subcircular shape, at least at its articular ends (Tab. VIII, fig. 3). The surface is very slightly and uniformly concave in most, with a slight central depression occupying about one third of the vertical diameter of the surface; but in some, as in fig. 3, there is hardly any trace of the median depression. The sides of the centrum are rather more concave lengthwise than in the cervical series, but least so at the lower part.

The following are dimensions of the dorsal vertebra:

	Plesiosaurus latissimus.	
	In.	lines.
Length of centrum	2	6
Breadth of ditto, at articular end	2	11
Breadth of ditto, at the middle	2	4
Height of ditto, at articular end	2	10
Vertical diameter of outlet of neural canal	0	10

The following are admeasurements of a dorsal vertebra, having a greater proportion of the neural arch preserved:

	In.	lines.
Length of centrum	2	8
Depth of terminal surface	2	10
Breadth of ditto	3	
Breadth of the middle of the centrum	2	5
From the under part of the centrum to the upper part of the diapophysis	4	3
From ditto to summit of neural spine	8	0
Fore-and-aft extent of neural spine	2	3

The chief changes observed in the middle dorsal vertebræ are the almost circular contour of the articular ends of the centrum, and the minor antero-posterior breadth of the neural spine.

Of one of the dorsal ribs an extent of fourteen inches in length is preserved; it shows two flexures; the first and shortest is concave upward, the rest convex upward and outward, for half the extent of the rib, the rest being straight. Many smaller parts of the ribs are scattered about the block of matrix.

The coracoids exhibit the proportional size, and broad expanse, characteristic of the genus; they are in too fractured and mutilated a state to serve for determination of any specific characters. One of the largest portions is figured in Tab. IX, fig. 2.

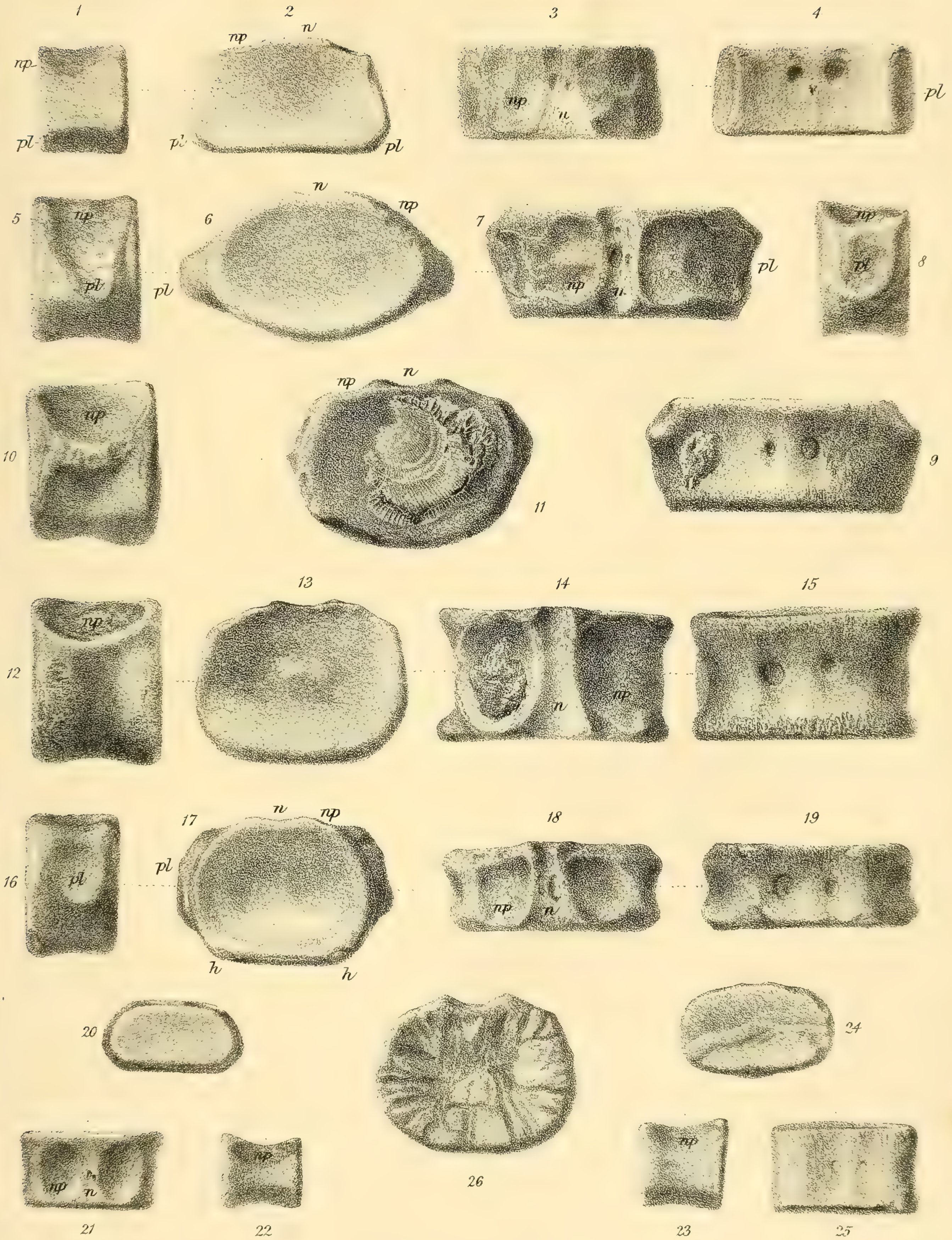
The ilium, five inches in length, and one inch in breadth at the middle, expands to both extremities by outgrowth from one and the same margin, which is thus made concave, whilst the opposite margin is nearly straight (Tab. IX, fig. 1). The upper expanded end is obliquely truncate. The lower one shows the articular facets contributed to the acetabulum, and to the other pelvic bones entering into the formations of that articular cavity.

TAB. I.

Plesiosaurus planus, nat. size.

Fig.
1. Side view of centrum of an anterior cervical vertebra.
2. Front view of ditto.
3. Upper view of ditto.
4. Under view of ditto.
5. Side view of centrum of a posterior cervical vertebra.
6. Front view of ditto.
7. Upper view of ditto.
8. Side view of centrum of a posterior cervical vertebra.
9. Under view of the same centrum as fig. 7.
10. Side view of centrum of the first dorsal vertebra.
11. Front view of ditto, with portion of the lower valve of *Dianchora striata* attached.
12. Side view of centrum of a dorsal vertebra.
13. Front view of ditto.
14. Upper view of ditto.
15. Lower view of ditto.
16. Side view of centrum of anterior caudal vertebra.
17. Front view of ditto.
18. Upper view of ditto.
19. Under view of ditto.
20. Front view of centrum of third (?) cervical vertebra.
21. Upper view of ditto.
22. Side view of ditto.
23. Side view of centrum of fourth (?) cervical vertebra.
24. Front view of ditto.
25. Under view of ditto.
26. Front view of centrum of a dorsal vertebra, with grooved articular surface.

From the Upper Green-sand near Cambridge. In the Woodwardian and British Museums.



J Dinkel del. et lith.

W West imp.

PLESIOSAURUS PLANUS.

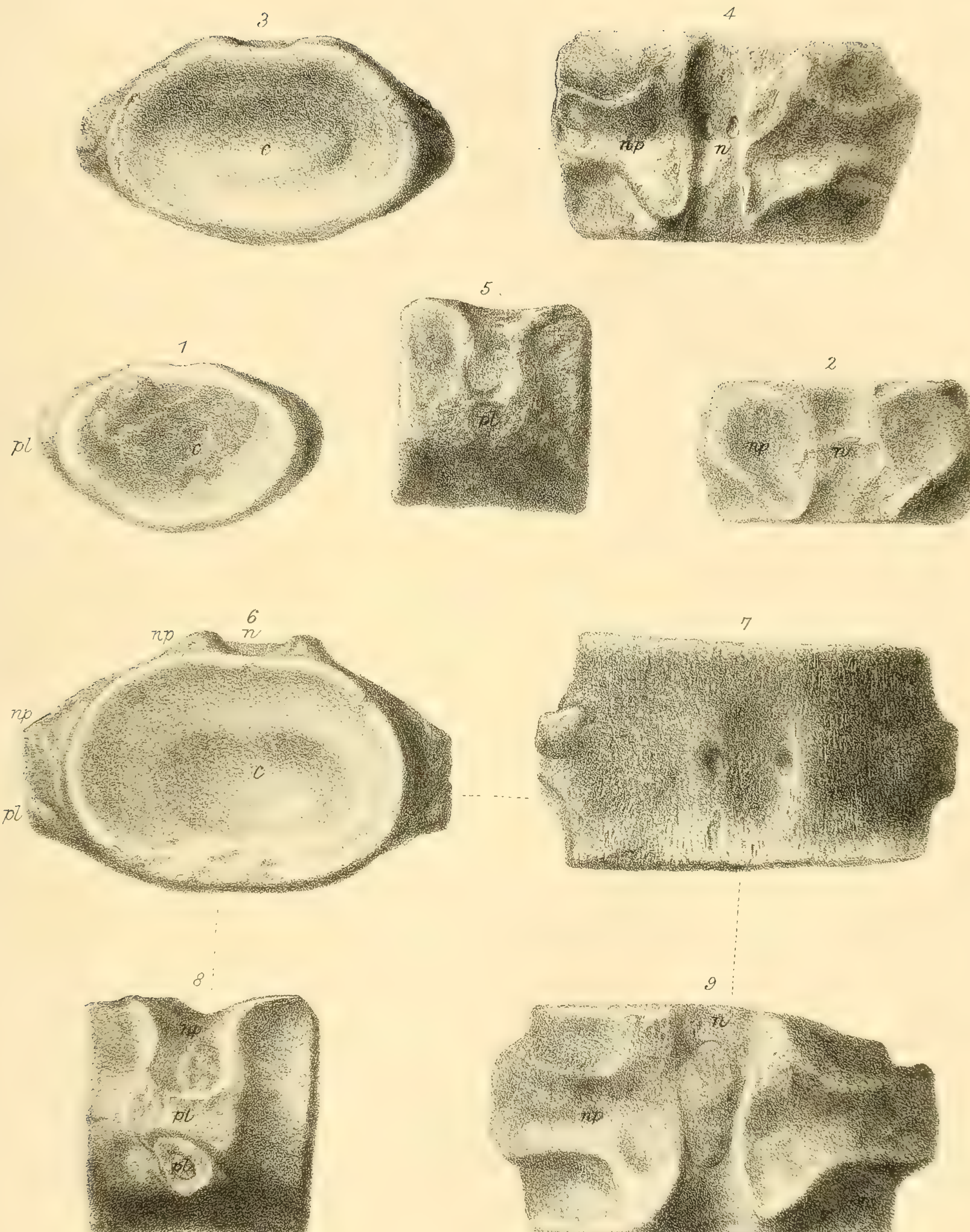
TAB. II.

Plesiosaurus planus, nat. size.

Fig.

1. Front view of centrum of posterior cervical vertebra.
2. Upper view of ditto.
3. Front view of centrum of posterior cervical vertebra of a larger individual.
4. Upper view of ditto.
5. Side view of ditto.
6. Front view of centrum of posterior cervical vertebra of a larger individual.
7. Under view of ditto.
8. Side view of ditto.
9. Upper view of ditto.

From the Upper Green-sand near Cambridge. In the Woodwardian and British Museums.



J. Dinkel. del. et lith.

W. West imp.

PLESIOSAURUS PLANUS.

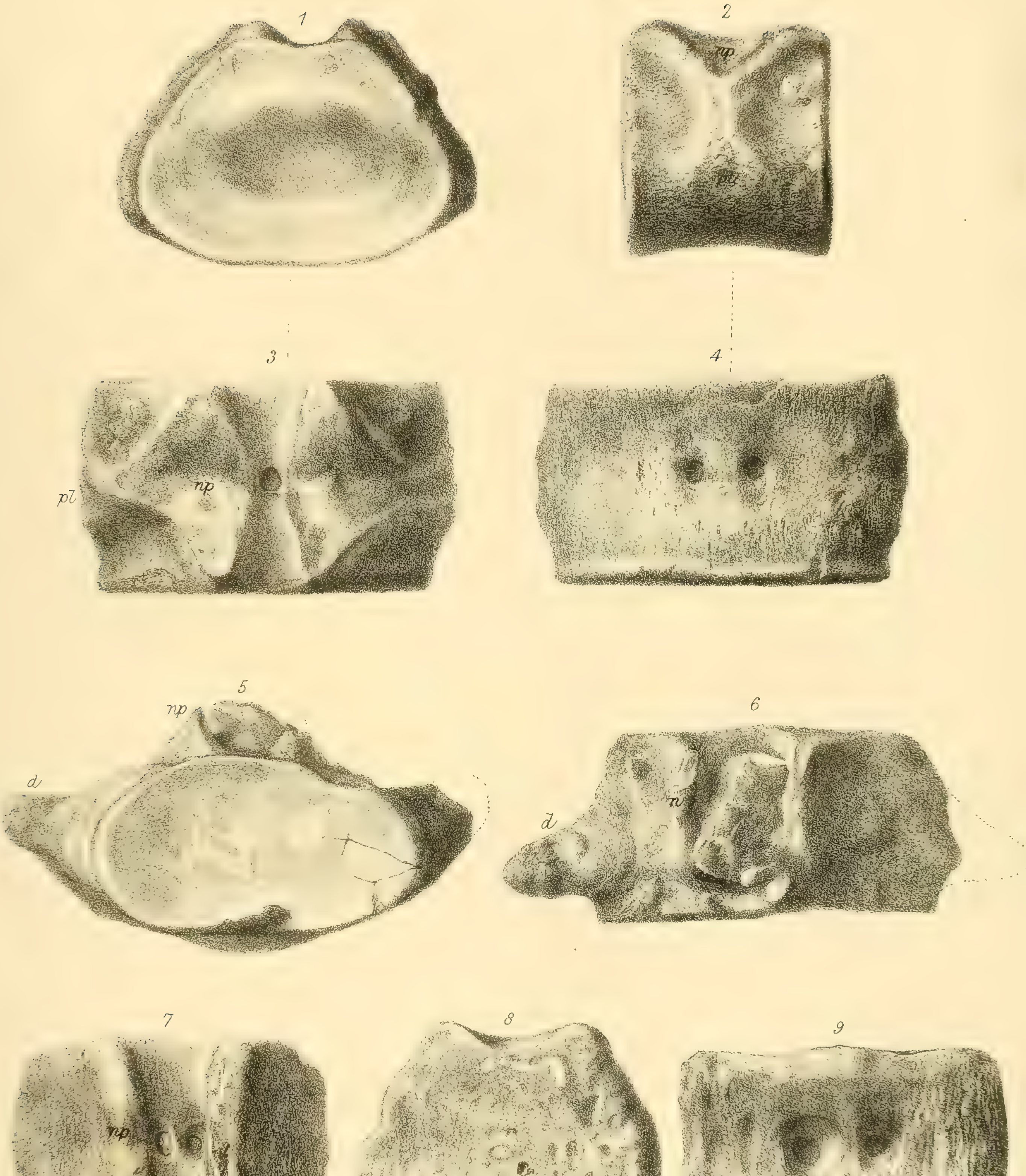
TAB. III.

Plesiosaurus planus, nat. size.

Fig.

1. Front view of a centrum from near the posterior part of the neck.
2. Side view of ditto.
3. Upper view of ditto.
4. Under view of ditto.
5. Front view of centrum of posterior cervical vertebra.
6. Upper view of ditto.
7. Upper view of anterior cervical vertebra, from an individual much larger than the one to which the vertebra, Tab. I, figs. 1—4, belonged.
8. Front view of ditto, with the surface abraded.
9. Under view of ditto.

From the Upper Green-sand, near Cambridge. In the Woodwardian and British Museums.



J Dinkel del. et lith.

W. West imp.

PLESIOSAURUS PLANUS; figs 1. .4, 7. .9, var. trigonalis.

TAB. IV.

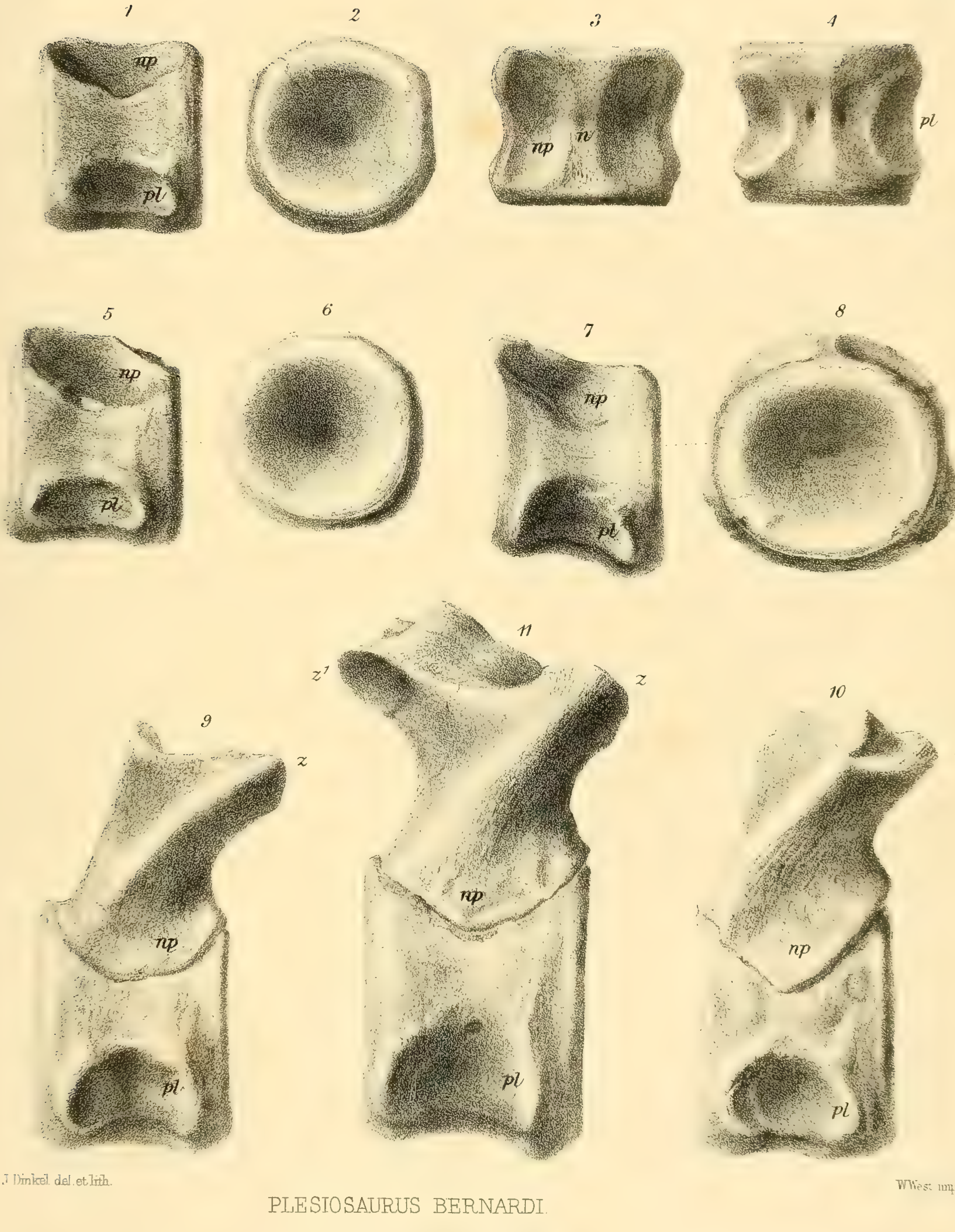
Plesiosaurus Bernardi, nat. size.

Fig.

1. Side view of centrum of an anterior cervical vertebra.
2. Front view of ditto.
3. Upper view of ditto.
4. Under view of ditto.
5. Side view of centrum of a cervical vertebra.
6. Front view of ditto.
7. Side view of centrum of cervical vertebra, slightly distorted by posthumous pressure.
8. Front view of ditto.
9. Side view of centrum and base of neural arch of cervical vertebra.
10. Side view of centrum and base of neural arch of a succeeding cervical vertebra.
11. Side view of centrum and neural arch, *minus* spine, of a cervical vertebra of a larger individual.

From the Upper Green-sand, near Cambridge. In the British Museum.

T. IV.



J. Dinkel del. et lith.

W West imp.

PLESIOSAURUS BERNARDI.

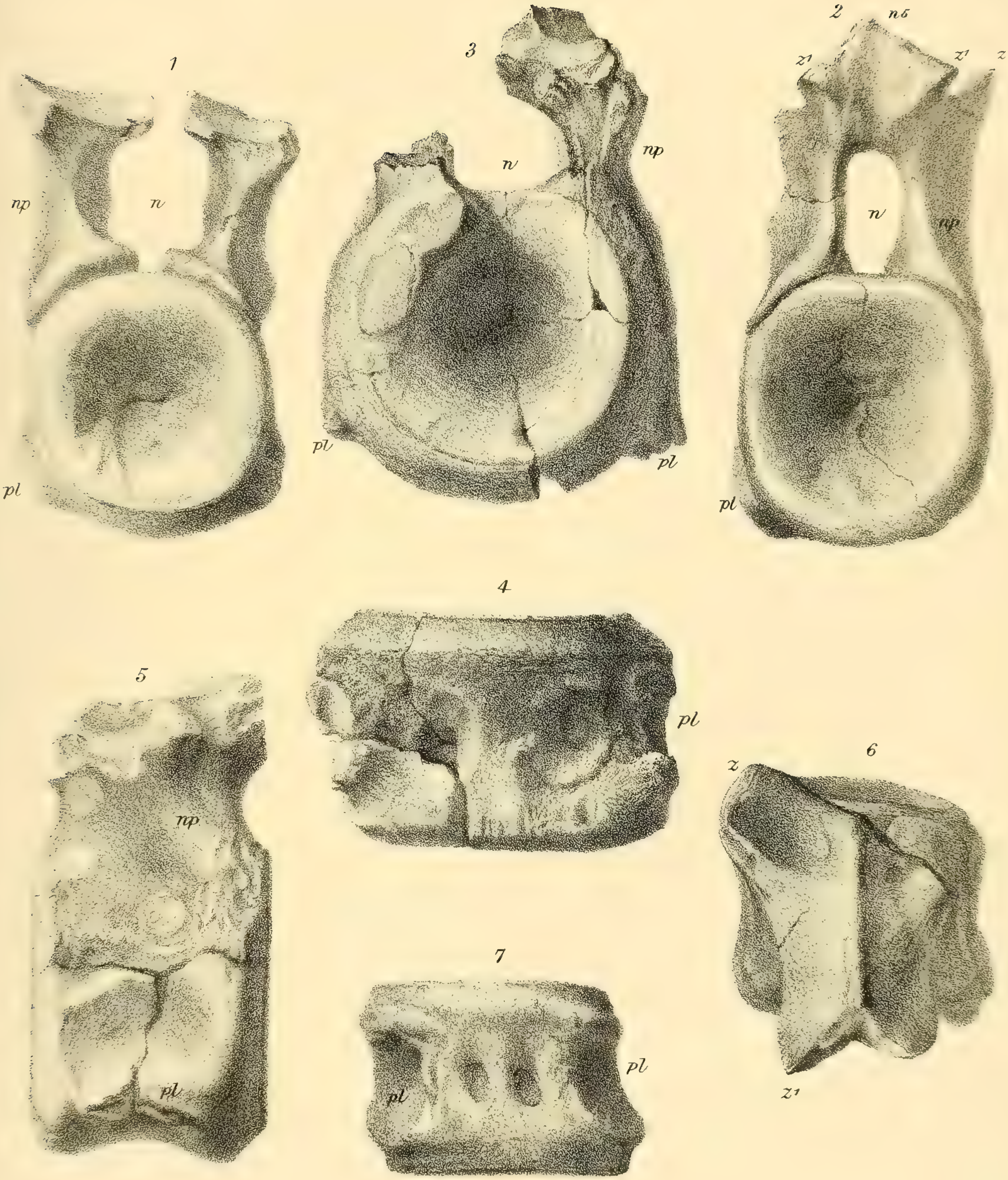
TAB. V.

Plesiosaurus Bernardi, nat. size.

Fig.

1. Front view of centrum and neurapophyses of cervical vertebra.
2. Back view of centrum and neural arch, *minus* spine, of cervical vertebra.
3. Front view of centrum and anchylosed base of neural arch of cervical vertebra of a larger individual.
4. Under view of ditto.
5. Side view of ditto.
6. Upper view of the vertebra, fig. 2.
7. Under view of centrum of cervical vertebra, slightly distorted by posthumous pressure.

From the Upper Green-sand, near Cambridge. In the British Museum.



J. Dinkel del. et lith. W. West imp.

PLESIOSAURUS BERNARDI

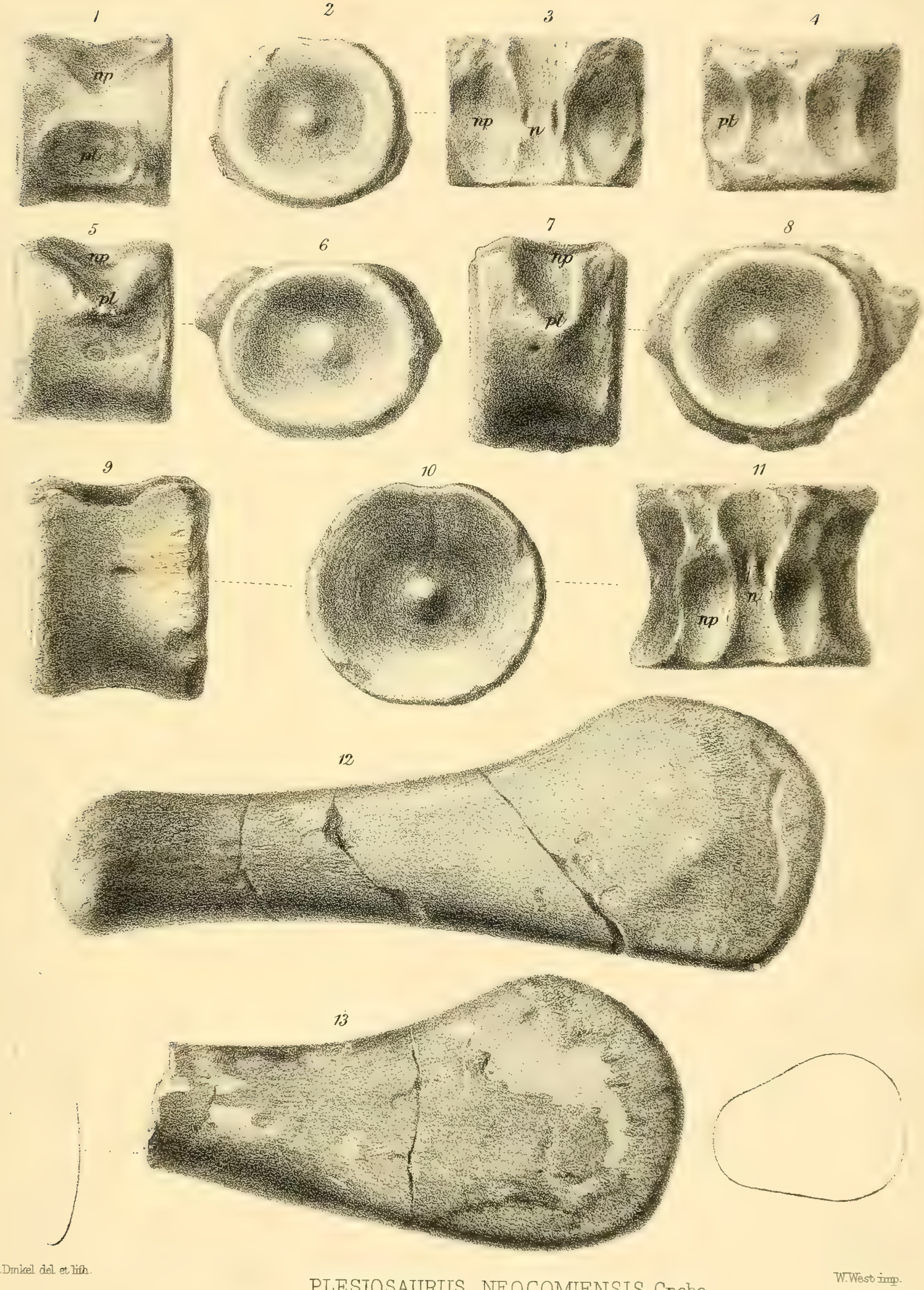
TAB. VI.

Plesiosaurus neocomiensis, Cpche., nat. size.

Fig.

1. Side view of centrum of cervical vertebra.
2. Front view of ditto.
3. Upper view of ditto.
4. Under view of ditto.
5. Side view of centrum of a posterior cervical vertebra.
6. Front view of ditto.
7. Side view of centrum of last cervical vertebra.
8. Front view of ditto.
9. Side view of centrum of a dorsal vertebra.
10. Front view of ditto.
11. Upper view of ditto.
12. Femur, side view, with outline of distal end.
13. Lower part of humerus, with sectional contour of the expanded portion.

From the Upper Green-sand, near Cambridge. In the Woodwardian and British Museums.



J.Dinkel del. et lith.

W.West imp.

PLESIOSAURUS NEOCOMIENSIS, Cpche

TAB. VII.

Plesiosaurus latispinus, nat. size.

Fig.

1. Side view of centrum of cervical vertebra.

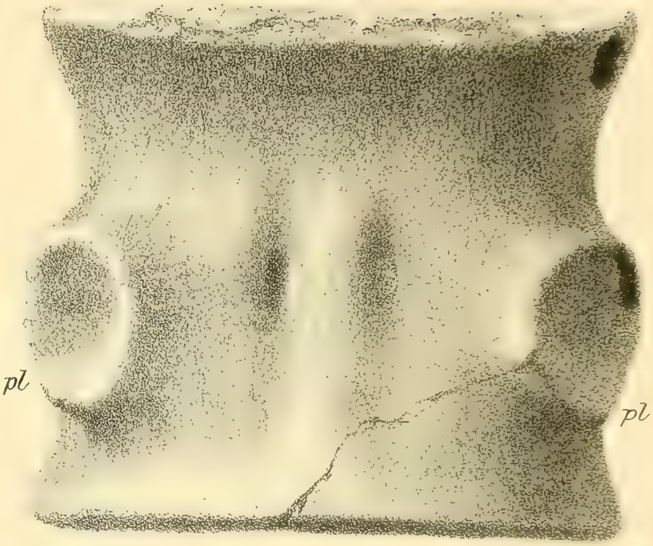
2. Under view of ditto.

3. Front view of ditto.

Discovered by Mr. W. H. Bensted in the Lower Green-sand of the Iguanodon Quarry, near Maidstone; now in the British Museum.

1

2



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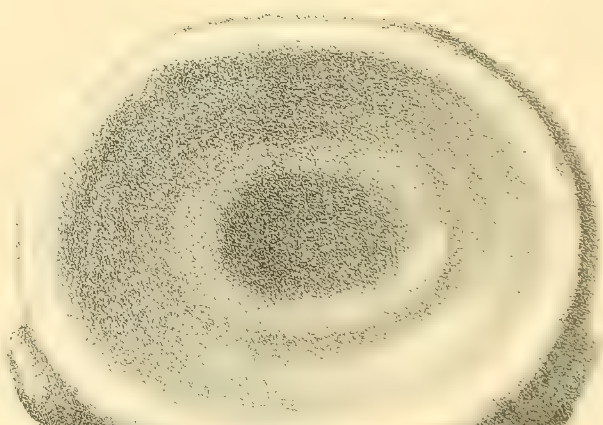


J. Dinkel del. et lith.

W. West imp.

PLESIOSAURUS LATISPINUS.

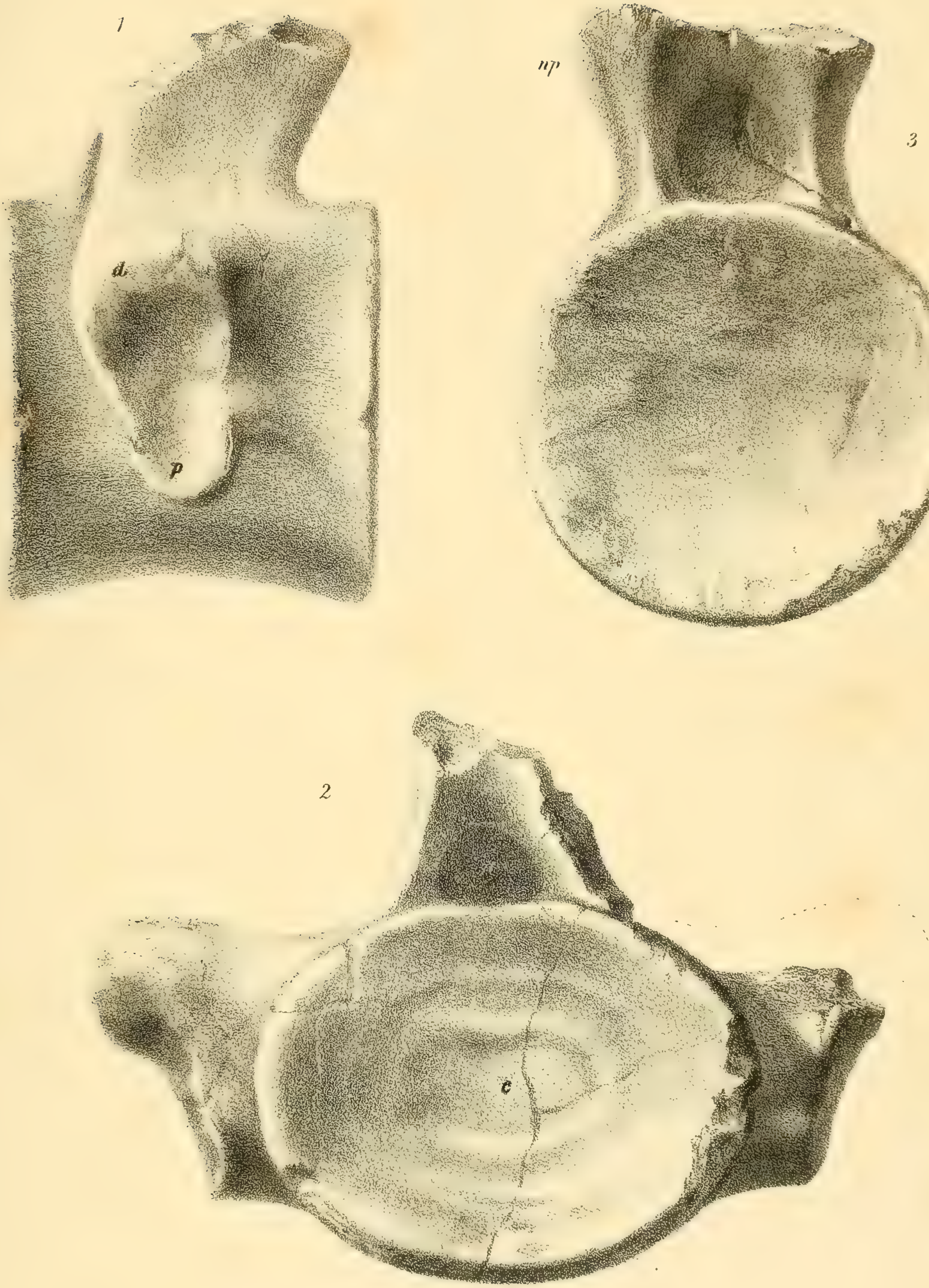
TAB. VIII.

Plesiosaurus latispinus, nat. size.

Fig.

1. Side view of centrum and part of anchylosed neural arch of a posterior cervical vertebra.
2. Back view of ditto.
3. Front view of centrum and anchylosed neural arch, mutilated, of a dorsal vertebra.

Discovered by Mr. W. H. Bensted in the Lower Green-sand of the Iguanodon Quarry, near Maidstone; now in the British Museum.



J. Dinkel del. et lith.

W. West imp.

PLESIOSAURUS LATISPINUS.

TAB. IX.

Plesiosaurus latispinus, nat. size.

Fig.

1. Right iliac bone.

2. Portion of left coracoid bone.

Discovered by Mr. W. H. Bensted in the Lower Green-sand of the Iguanodon Quarry; now in the British Museum.

J Dinkel del. et lith

W West imp

PLESIOSAURUS LATISPINUS